ASIAN
IOTECHNOLOGY AND DEVELOPMENT
REVIEW

February 2002

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**Research and Information System
for the Non-Aligned and
Other Developing Countries**

Asian Biotechnology and Development Review

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The *Asian Biotechnology and Development Review (ABDR)* aims at generating wider awareness of the issues involved and emerging developments in the area of biotechnology. It hopes to serve as a forum of debate and dissemination of information on issues such as developmental potential of biotechnology, and the possibilities of South-South cooperation in this area. *ABDR* is a continuation of *RIS-BDR* series (Vol. 4 No. 2).

The cooperation and support received from the Life Science Section of UNESCO, Paris, France, and Department of Biotechnology, Government of India, New Delhi in bringing out this journal is gratefully acknowledged.

The editorial correspondence should be sent to the Managing Editor, *Asian Biotechnology and Development Review*, Research and Information System for the Non-Aligned and Other Developing Countries (RIS), Zone IV-B, Fourth Floor, India Habitat Centre, Lodi Road, New Delhi-110003, India. Telephones: 4682177-80. Fax: 91-11-4682173-74. E.mail: risnodec@del2.vsnl.net.in Website: www.ris.org.in

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P 10,997

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Printed by: Multiplexus (India), 94, B.D. Estate, Timarpur, Delhi-110 054 (India)
Ph. 395 2438, 3924775 & 7103 Fax: 91-11-3940912 e-mail: multipxs@del3.vsnl.net.in

Cuk-H03801-1-P010997

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Bioindustrial Revolution and Economic Development: Evolving Indian Strategy

Manju Sharma*

India has recognized the need to harness science and tecnology for the socio-economic progress of the country. In fact, India has made concerted efforts to speed up the research and development, application and commercialization of research findings. The Twenty-first century is the age of modern biology, as has been said by Walter Isaacson, *"Ring farewell to the century of physics... It is time to ring in the century of biotechnology."* One may even call it a "Century of Genes" or "Gene Technologies". All these expressions are of great excitement to people at large and the scientific community in particular. The realization that genetic diversity can be converted into economic wealth and the enormity of biological resources of a nation or a region can be a major feed stock of biotechnology industry. The excitement has moved from the domain of intellectual curiosity to economic and societal benefits. A bioindustrial revolution is thus on the anvil.[1]

The developments in applied biotechnology are directed towards economic production of new and conventional biological products for widespread human use. This would give an impetus to economic development.

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Importantly, biotechnology is aiming at higher yields from agriculture with reduced inputs and to provide affordable diagnostics, pharmaceuticals, vaccines and therapies for preventing and curing human diseases. Both these approaches will have concomitant impact on industrial growth.

The World over, the word biology is used truly in a very broad sense. It represents an inter-disciplinary field integrating material science, physics, biology, mathematics, information science and many other areas of agriculture and medical research. The advances in genetic engineering, biochemistry and bio-engineering have resulted in a wide range of biotechnologies. Bioinformatics and biotechnology are intertwined. The latest 'through-put' systems to the bioinformatics set up, high performance computers, DNA amplification and sequencing, genome assembly and gene production, proteomics and mass spectroscopy, development of biochips, better gene expression systems and so on. All these tools are leading towards more exciting research opportunities. A recent report from United States, Switzerland and many advanced countries from a group of scientists indicates that they can make simple, artificial cells from scratch. These can metabolise, replicate and evolve, i.e. fulfill the basic criteria for the living entities. While they will only be synthetic, the scientists have said: "This would mark the beginning of the field of synthetic biology".

To realize the full potential of biotechnology we certainly have to go a long way in conducting basic research on all aspects of modern biology; the knowledge base needs to be continuously expanded. But what is more important in biotechnology is to nurture the leads of potential utility in the areas of agriculture, healthcare and environment. We need to have demonstrations, field evaluations, and pilot level productions; through partnerships with industry thus we can move towards bioproduct development for the market place.

We must also know two aspects of biotechnology research; first a long gestation period and second the ethical, safety and social concerns. We should make promises to fulfill the aspirations of the people at large, but the promises should be such that they are realizable in a short span of time. Our assessment is that continuous support from the Government to speed up research and development in biology and biotechnology with the infrastructure already created in many areas, which certainly needs extension and augmentation, with well set policies and regulatory procedures. We have to identify the areas where we have strength, niche and can become world leaders.

Industrial Advancement

It is logical that whenever new innovations and research leads emerge, before going for their application, adequate validation, safety protocols and rigorous testing is required. There has been concern expressed by some sections of the society about the biosafety of the biotechnology products. It has been quoted that in Europe, the GM products are still not allowed and there has been a restriction on genetics and biotechnology research. It is very heartening to see that on 29th November this year, the full Eurpoean Parliament rejected the report of a 72 Member Committee on imposing restrictions for genetics and biotechnology research. The researchers are extremely happy on this decision.[2]

When we are talking of biotechnology industry, particularly the start ups, it is felt that there is need for some seed investment even by public sector. In fact, in France they have allowed a big boost to the biotechnology sector by injecting public money into some private biotechnology companies. They have a law that the publicly supported researchers can become shareholders in companies linked to their laboratories. These are all methods of bringing the research leads to the market place. The "New" Biotechnology is defined as : *"The industrial use of rDNA, cell fusion and novel bioprocessing techniques."* However, further it was considered that the definition which will go a long way should relate to the world economy; thus according to Vivian Moses and a corporate biotechnology pioneer Ronald Cape (1991), it is defined as *"Making money with biology."*

Biotechnology has witnessed major scientific and technological revolutions in the last Century and has greatly influenced various aspects of human life. It is a key technology for the future development of most countries. New breakthroughs in genomics, healthcare, food, agricultural products and environmental protection have largely emerged as a result of advances in this field. Biotechnology provides powerful tools for the sustainable development of agriculture, fisheries and forestry, as well as the food industry. When appropriately integrated with other technologies for the production of food, agricultural products and services, biotechnology would meet the needs of an expanding and increasingly urbanized population in this millennium and would certainly be for the rapid progress of rural areas. The new tools responsible for a bioindustrial revolution are genetic engineering, cell fusion technology, gene technology, mapping, sequencing, analysis, bioprocess technologies and structure based molecular designs. The pharmaceutical sector has had maximum benefit.

Industrial biotechnology sector relates to all areas which use modern biological, rather than conventional techniques to develop commercial products for agricultural productivity, human and animal healthcare, environment and food processing. Biotechnology is one of the most research-intensive industries in the world. In India, consumption of biotechnology products increased from Rs. 71.54 billion in 1997 to Rs. 94 billion in 2000 and the projected demand for 2005 is around Rs. 145.6 billion.

The industrialization of agriculture is increasing. Due to liberalization in international economy and globalization, the farm products are now highly competitive. In order to survive in the market they must produce more, acquire the best varieties and use the most advanced techniques, specially biotechnological tools. Precision farming and molecular markers aided breeding practices are no more research concepts. They are a reality today. Use of tissue culture for producing large quantities of elite planting material, development of transgenic plants resistance to biotic and abiotic stress, effective production of improved strains of biofertilizers and biocontrol agents, improved livestock varieties and improvement in the aquaculture sector are happening now. In fact an integrated approach of agriculture and natural resource management is widely applicable.

Key developments reported this year in biochemistry, biotechnology and molecular biology include studies on molecular transporters that help drugs enter cells, proteins with unnatural residues, infinite-affinity antibody-ligand pairs, previously unknown antibody functions, salt-tolerant plants, the mechanisms of action of an important drug and an enzyme, and a series of studies in the areas of carbohydrate chemistry and structural biochemistry.[3]

Scientists in the USA and in Canada have created genetically modified tomato plant that flourish on a diet of salt water. The fruit is healthy and tasty.[4] The researchers engineered to produce high levels of an ion-shuttling transport protein. This phenomenon can be a boom extended to other groups, specially where there is a prominence of salt water

Developments in Transgenics

The successful application of biotechnology for production of desired crops to address issues related to malnutrition, poverty, increased productivity, desirable traits, insect and disease resistance have opened vast avenues for rapid industrialization of this technology. The number of countries growing transgenic crops has increased from 1 in 1992, to 6 in 1996, to 9 in 1998 and 12 in 1999. The total area under transgenic has increased from 1.7 million ha. in 1996 to more than 40 million ha. in 2001. Between 1995 and 1998 the value of the global market in transgenic crops grew from US$75 million to US$1.64 billion. The market is projected to increase to $6 billion in 2005, and to $20 billion in 2010.[5] Today nearly 30 agricultural biotechnology products are in the market and an equal number are being tested for release.

In India, transgenic potato with high nutritional quality has been developed with the introduction of AmA1 gene isolated from *Amaranthus*. Transgenic plants of cotton, rice, mustard, mungbean and tomato are being produced for field evaluation. An autonomous National Centre for Plant Genome Research (NCPGR) has been set up at New Delhi working on the genomics of plants like *Cicer* and *Catharanthus*. A major programme on rice genome sequencing has been initiated, as a part of the International Programme. A National containment/quarantine facility for transgenic planting material has been setup at NCPGR, New Delhi. The main focus of the facility is on quarantine aspects of transgenic plants and also human resource development activities, to meet the future requirements in this field.

The biotechnology industry in a short span of time has become a multi billion dollar industry. Current techniques for in vitro propagation of plants and the ready acceptance of tissue culture raised plants by the commercial sector, have allowed for continued growth within the micropropagation industry. It is reported that over 796 commercial companies are engaged in such activities all over the world and their number is increasing. Annual plantlet production is approximately 900 million plantlets. In India, there are nearly 70 registered companies with approximately 30 companies having immediate plans for selling tissue cultured plants and more than a dozen already in the market with their products. Annual production is estimated at approx. 50 million plantlets, however, the installed capacity is nearly 150 million. Tissue cultured planting material of fruit crops like banana, strawberries, grapes, papaya, cardamom and ornamental flowers such as gerbera, carnation and orchids is available besides a number of foliage ornamentals.

Role for Department of Biotechnology (DBT)

We see enormous strength and capability in our institutions such as the NII, New Delhi; the NCCS, Pune; the CDFD, Hyderabad; the CCMB, Hyderabad and the CDRI, CIMAP, NBRI, ITRC etc. in Lucknow; the new centers like the Brain Research and Plant Genome Research etc. also in the university systems and of late in the industrial sector. So, we have the desired capability, infrastructure, resource base, and also the funds, at least, for all the high priority programmes. It is just a matter of organizing ourselves in a directed approach to look at the problems and to come up with solutions. DBT has played a pivotal role in promoting the commercialization of plant tissue culture. A vast network programme covering nearly 80 research institutes/universities has been working on protocol development of 60 different species. Twenty technology packages have been perfected. Two Micropropagation Technology Parks, set up by the Department at NCL, Pune and TERI, New Delhi have successfully transferred, 5 technologies to the Industry. Nearly 10 million plants have been field planted over 8000 ha. area. Data on the cost benefit ratio and returns from TC plants indicates that there is a higher net profit. The demonstration plot of Eucalyptus at farmers land has demonstrated higher growth rates, early rotation leading to higher cost: benefit ratio (1:3). Wood volume of tissue culture raised plants was 45 cu.m./ha higher and fetched 38.91 per cent more value of wood, which resulted in higher net profit of 42 per cent. Five time increase in biomass and yield has been reported in banana. TC sugarcane reports 1½ times increase in yield and 1 per cent increase in sugar content. In TC Cardamom nearly 40 per cent increase in yield has been reported vis-a-vis the open pollinated seedlings.

A National Facility for Virus Diagnosis and Quality Control located at IARI, New Delhi, with 5 satellite centres, is for Virus Diagnosis. Diagnostic kits are being developed. The quality control specially for the forest trees is being certified using molecular markers and DNA finger printing techniques. The planting material will be indexed and certified for the industry, and other research institutes/organizations involved in the large scale production of tissue culture plants.

DBT has facilitated development of several packages of new technology by the farming communities. The biofertilizer technology has been demonstrated benefiting nearly 20,000 farmers. The technology for production of mycorrhizal biofertilizer has been transferred to the industry. In the area of biocontrol agents 75,000 ha. has already been covered and

35,000 farmers have been benefited. An anti-fungal formulation for control of root rot disease was developed and transferred to the industry. Four fermentor based technologies for biopesticide production have also been developed and transferred to the industry. Botanical pesticide developments have been taken up with an industry with their financial contribution. The area of environmental biotechnology, specially the bioremediation technology has enormous commercial potential. The eco-restoration technology for re-vegetation of degraded land has been successfully transferred to the industry. Another important product which is today being scaled-up for commercial production is the crude oil and oil sludge degrading bacterial consortia named "OIL ZAPPER".

Bioresource development, inventorisation, characterization and documentation of the precious bioresources of the country has already been initiated, covering microbial, marine, economically important plant and animal resources. Bioprospecting of the plant species from critical ecosystems, herbal product development from medicinal plants with very promising leads are the other initiatives. Biotransformation and scale up studies are under-way.

To provide low cost, affordable, easy to use health care system through the inputs of biosciences is one of the most challenging goals for the bioscientists in the 21st Century. A large proportion of the global investment in biotechnology goes to the healthcare sector – both human and animal. Biotechnology based healthcare products are likely to dominate the market at about 40 per cent of the consumption level. Monoclonal and polyclonal antibodies for disease immunodiagnosis, tissue typing, clinical assays and research constitute a large proportion of the market. The potential of the diagnostic market is very high and is also anticipated to be very diverse considering the growing population, the declining status of health, the emergence of infection disease etc.

Currently in India, eight industrial units have taken steps to produce r-DNA products in health care area. Globally there are about 35 biotechnology - derived therapeutics and vaccines in use and over 500 additional drugs and vaccines are in various phases of clinical trials. Biotechnology has spurred growth in diagnostics and over 600 biotechnology-based diagnostics are now available in clinical practice with a value of about US $ 20 billion. Many more are about to enter the market, the most prominent among these will be PCR - based diagnostics. In India the diagnostic sales are expected to be between Rs.1 billion - Rs.2 billion. At present we rely on imports for many of the immunodiagnostics kits. But in the last 2–3 years, indigenous kits of HIV, Hepatitis-C, dengue, Hepatitis-A and many others have gone to industry. Gene therapy offers the potential to correct diseases at the genetic level.

Through the efforts of the DBT, projects have been implemented in the areas of major infectious and non-infectious diseases, viz. tuberculosis, HIV, malaria, leishmania, cholera, dengue, typhoid, cancer and heart diseases. Technology for 11 diagnostic kits has been validated and transferred to industry. In the area of DNA vaccines also very good leads have been obtained, specially in cholera, rabies and JEV. Clinical trials are underway. These products would be ready for use very soon.

A land mark in scientific research last year was the availability of the first draft of the human genome sequence. Almost a substantial complete version of 2.9 billion pair sequence was available opening up major implications for the development of new drugs, genetic therapies, etc. The most striking part of this break-through is the understanding that the number of human genes are small between 30,000 to 40,000 in comparison to what was estimated in 1991 as 100,000. Based on these, we have had major accomplishments in genomics and chemistry related areas, specially about diseases.

DBT proposes application of biotechnology will be used to ameliorate economic conditions of a sizeable fraction of 55 per cent of the Indian families engaged in agriculture, which are at present suffering on account of recent decline in the competitiveness of Indian agriculture. Careful diversification of cropping patterns will enlarge India's presence in the global markets for value added agriculture products. Utilization of genetically engineered crop varieties will improve farm level economics of agriculture. Some of these new copping patterns available will bring into farmers from their level 50-300 per cent.

Several biotechnological programmes for the benefit of SC/ST population, women and rural areas have been implemented by the DBT in the areas of biopesticides, biofertilisers, vermicompost and vermiculture, sericulture, floriculture, mushroom cultivation, medicinal plant production, poultry, fish farming and improvement of human health. Nearly 60000 families have been benefited. In order to generate a critical mass of expertise, a strong infrastructure, significant investment and mobilization of the capabilities of educational institutions would be necessary. More than 62 teaching programmes are being operated at present in various universities and academic institutions.

Developments in Bioinformatics

Bioinformatics is an emerging interdisciplinary field of biology. It incorporates the advances in information technology and those of molecular biology in addressing a number of biological problems. The explosive growth of bioinformatics can be attributed to the astronomical increase in sequence information generated by the genome projects. Analysis of this sequence information is likely to reveal not only the location of genes, but also help in predicting the protein structures coded by them. This again provides valuable clues to the function of the cell and phenotype of the organism.

In the global arena bioinformatics is progressing at an astonishing rate. The need for coordination and composite data management has resulted in the development of the International Nucleotide Sequence Database Collaboration among the three key organisations – GenBank, EMBL and DDBJ. At the current pace of sequence information accumulation, the GenBank doubles every six months and the rate is likely to pick up.

Apart from these, bioinformatics also covers some of the more generic areas, such as the documentation of all known species on the earth [biodiversity informatics], germplasm information and so on. Major disciplines to be benefited from the strides of bioinformatics include agricultural biotechnology, pharmaceutical science, medical science, and environmental science, to name a few.

In India, the bioinformatics programme currently spans 21 states of the country with an array of 10 Distributed Information Centres and 56 Distributed Information Sub-Centres. The entire network is coordinated by the Apex Bioinformatics Centre at DBT. The primary thrust of the programme, during the preceding fifteen years of its existence, had been development of infrastructure facilities and manpower development for harnessing the genome revolution. The programme is now in a position to utilise the available facilities to promote mainstream bioinformatics initiatives in the country. The primary objectives to be addressed during the future course of action would be:

- Bioinformatics resource building by the centres to achieve self-reliance in the field of biotechnology information;
- Integrate the entire network and develop it as an unified knowledge base in biotechnology and molecular biology;
- Develop an Integrated National Bioinformatics Policy;
- Develop public utility packages, in terms of software and databases, in the field of bioinformatics;
- Promote close liaison with the industry;
- Enhance development of trained manpower;
- Promote state-of-the-art research in bioinformatics; and
- Initiate a suitable platform for interaction of bioinformaticians and computational biologists of India.

Future Perspective

To integrate information and biotechnology revolution as a single technological and economic force, one requires to establish a large number of biological data banks. Transgenics is an important strategy in agriculture, which would produce bioengineered crops to become source of enzymes, vaccines, biochemicals, etc. Crops with resistance to biotic and abiotic stresses such as salinity, drought and water logging; nitrogen fixation in cereals using more efficient microbes and value addition along with nutritional enhancement of important edible crops would be a mission.

In vitro mass propagation of the desired planting material, genetic control through identification and manipulation of genes and its implication in the forestry sector would help in rapid regeneration of forests and also result in the enhanced production of industrial timber.

Development of a large number of diagnostics for major diseases, genetic disorders, cancer, tuberculosis, HIV, malaria, better understanding of the human brain from molecular to systems level to enable control and treatment of large number of currently uncurable neurological disorders and development of new generation vaccines including the DNA vaccine would move fast. Our inherent strength of Ayurveda and traditional systems of medicine would be optimally utilised through biotechnological interventions. Realising that the present century would greatly depend on medicines from plant-based systems, development of new molecules, drugs, prospecting of new genes and the whole field of pharmacogenomics would be a mission. In fact, new areas such as toxico genomics, proteomics are all the identified priorities.

It is becoming increasingly obvious that systems that combine biological and chemical molecules on the one hand, and physical devices and electrodes on the other, have a huge potential for many applications. The biotechnology industry is just coming out of its infancy. Its potential is being tested, realised and used. The public awareness and acceptance will accelerate the process. This sector is expected to expand at least 3-fold by the end of the century and will match or surpass the computer industry in size, importance and growth. Currently, these are being supplemented by private individual entrepreneurs for developing appropriate goods and services for local needs as well as for the export market. Technologies are also flowing into the country due to the changed economic scenario. Very soon we can become global players in at least some areas of biotechnology: herbal, agricultural, microbial or genomics – may be in all. As long as our basic objective is to harness this field for human welfare, we will succeed.

Endnotes

[1] Based on Presentation on "Biotechnology – The Frontier" at the Indian Science Congress, Lucknow, 4th January, 2002.

[2] Nature, 6th December 2001.

[3] Highlights C&EN, December 2001.

[4] Nature Biotechnol., 19, 2001.

[5] ISAAA, 1998.

Agro-Ecosystems: Challenges and Opportunities

R. S. Rana*

1. Introduction

Agro-ecosystems stand out from the natural ecosystems as they have been created and managed by human beings for their own use. These may often overlap with forests, grasslands and coastal ecosystems where croplands may form part of a mosaic of land uses. Around 37 per cent of the global land is under agriculture including the managed pastures (FAO 2000). Global agriculture provides 95 per cent of all animal and plant protein and nearly 45 per cent of the world's population (even over 80 per cent in some developing countries) is reported to be living in households dependent on agriculture (FAO 2001).

Reported declining trend in their condition and capacity notwithstanding, it is remarkable that agro-ecosystems have been successful in terms of their ability to keep pace with the increasing demands of ever growing human and livestock populations for food, feed, fiber and other items. There appears to be little scope for bringing more land under agriculture in future and it has become essential to obtain more output from a given area. Intensification of agricultural production has progressed rapidly as irrigated farmland expanded, the use of purchased inputs and adoption of new technologies grew, fallowing time decreased and cropping intensity increased. However, agriculture faces enormous challenge of meeting the food needs of an additional 1.7 billion people, projected as the population increase over the next 20 years, particularly when almost 65 per cent of cropland worldwide has already undergone some degree of soil degradation and over pumping of groundwater by farmers exceeds the recharge rates in many areas. Some of the findings from WRI (2000) are as follows:

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1.1 Recent Findings (WRI 2000)

- Food production is still likely to continue to rise significantly in coming years in response to the increase in demand but soil health appears to be deteriorating at an alarming rate. Continuously adding more purchased inputs supported by new technologies may offset a part of this setback but regional disparities are likely to widen hitting the poor the hardest.
- Water quality is on the decline. Adverse impact on quality of downstream groundwater is bound to increase due to heavy leaching of chemical inputs (fertilizers, pesticides, etc.) while problems of water logging and salinization will pose more serious threat under irrigated agriculture wherever drainage facilities are inadequate.
- With nearly 17 per cent dependence of crop lands on irrigation, agriculture is currently the largest user of freshwater globally. Hard competition with other kinds of water use, particularly for drinking and industrial needs, is likely to grow further and pose a serious problem.
- Agricultural biodiversity, the cream of natural biodiversity selected and enhanced by humans for their use over the past ten centuries, is on the fast decline track – both in terms of crops and also their traditionally grown varieties. Narrowing genetic bases and increasing crop and varietal uniformity over large contiguous areas usually mean more vulnerability to widespread incidence of diseases and pests and this may imperil food security, global trade in agricultural produce and products and, most of all, the livelihoods of small farm families.

Box 1. Agro-biodiversity and Agricultural Ecosystems

Agricultural biodiversity (or agro-biodiversity) is a sub-set of biodiversity that is the result of the careful selections and innovative developments of farmers, herdsmen and fisherfolk over more than ten thousand years and also includes progenitors and close relatives of cultivated plants and domesticated livestock. Agricultural biodiversity has also been remarkably increased by the contributions of professional breeders engaged in plant and livestock improvement programmes. In general, agro-biodiversity refers to the variety and variability of plants, animals (including pollinators and predators) and microbes on earth that are important to food and all other agricultural production systems along with management systems and traditional practices used by farmers and farming communities.

Agricultural Ecosystems (or Agro-ecosystems) are those highly diverse ecosystems that are used for agriculture in similar ways, with similar components, similar interactions and functions (FAO 1999). These include the genetic resources, the physical environment, the human management practices and their interactions. Their processes are reflected in functioning of farming systems comprising croplands, animal husbandry, pastures, aquaculture, agro-forestry and other land-use systems. They may be managed as monocultures, polycultures or mixed systems in numerous combinations like crop-livestock systems and agro-silvi-pastoral systems.

- Regarding carbon storage, signals are unclear at present. Data collection methodologies and analysis techniques remain contested. Agro-ecosystems, overlapping grasslands and forests to some extent, store 26 to 28 per cent carbon and their management styles can impact concentration of carbon dioxide in the atmosphere. This concentration has increased significantly during the last century, but apportioning contributions to different ecosystem categories is difficult at present.

To sum up, these findings paint a grim picture despite low resolution but they are mostly along the accepted lines and convincing also. It is widely believed that the web of life is fraying, but inferences vary regarding the extent and reversibility of the damage to life support systems. WRI takes due note of this point while stating that "we currently lack much of the baseline knowledge we need to assess ecosystem conditions adequately on a global, regional, or sometimes even on a local scale". It also pleads for vigorous support to a more comprehensive Millennium Ecosystem Assessment that is likely to begin soon. It concludes on a positive note that useful experiences are available around the globe to check, contain and repair the observed damages, in great measure if not fully. There are still workable options but time for action is running out.

1.2 Developing Countries Perspective

Extent

Findings of the WRI (2000) bring out several contrasting features between the developed and developing worlds when global generalizations are attempted to be resolved at the regional and national scales. Firstly, data collection, storage and reporting systems are not yet adequately developed in a large number of developing countries, where short cuts often substitute systematic surveys. Secondly, averages based on selected information are used to show the trends but these scores mask more meaningful information than what they convey. For example, WRI quotes FAO 2000 statistics to state that 69 per cent of agro-ecosystems consist of permanent pastures while the remaining 31 per cent are under crops on the global scale (FAO 2000). However, pastureland makes up 89 per cent of agro-ecosystem area in Oceania, 83 per cent in Sub-Saharan Africa, 82 per cent in South America and 80 per cent in East Asia. On the other hand, croplands occupy 92 per cent of agro-ecosystem area in South Asia and 84 per cent in Southeast Asia. Crops cover nearly 94 per cent of agro-ecosystem area in India. There is further significant variation even in croplands when we compare areas under annual grain crops, fibre crops, oilseeds, vegetables, fruits, plantations and other crops. While knowing global trends serve a useful purpose in developing global strategies and funding priorities, policy decisions and administrative measures relate to the scenario obtaining at the national, state or even smaller administrative boundaries where ecosystems function and people live in them. This discussion suggests that local people need to be involved in assessment of the condition and capacity of ecosystems rather than relying on information that is gathered for a different purpose altogether but used for making assessments.

It is noteworthy from the reported data that agro-ecosystems cover nearly 36 million km^2, occupying about 28 per cent of land area with sizable differences in regional shares. Combined share of Asia, Africa and South America is 64 per cent while that of Europe, Russia and North America is 35 per cent. It is also remarkable that out of the estimated 2.8 billion people living in or near agro-ecosystems, nearly 2 billion live in Asia. These findings have obvious policy and planning implications.

Conversion

When farmers convert a natural ecosystem to agriculture, they usually change both the composition of the ecosystem and how it functions. Agriculture in converted areas may also increase pressures on surrounding ecosystems through the introduction of non-native species that may become invasive and displace indigenous species. It is notable that bio-invasions are considered second only to habitat loss (usually through conversion) as a threat to global biodiversity. Not all conversions are, however, equally damaging. Some, like the traditional agro-forestry systems in many Asian countries, may retain several features of the original ecosystem. Synergistic cultivation of the shade-loving large cardamom in forest area in Sikkim state of India by the Lepcha community illustrates this point in actual practice.

FAO statistics reveal that the total area under agriculture has expanded by about 8 per cent globally, during the 30 years period beginning 1966. At national scale, however, land conversion, both to and from agriculture, has taken place at much higher magnitude with contrasting patterns observed in the industrialized and developing countries. Components of these aggregate values are more relevant from an ecosystem perspective since they show the dynamics of change. The overall expansion at the global level notwithstanding, agricultural area actually decreased in the United States, Europe and also in Oceania though for different reasons. Whereas South Asia's total agricultural area has remained almost unchanged during the past 20 years, agricultural land increased by nearly 0.8 per cent per year during 1986-96 in China and Brazil and by 1.38 per cent per year in West Asia (FAO 2000). These dynamic patterns of conversion at the national and regional levels and also the causal factors are of greater relevance to the ecosystem management. Number of people engaged in agriculture and the sizes of operational farm holdings are also important considerations to give human face to agro-ecosystems.

Intensification

With the demand for agricultural produce rising steeply and good agricultural land becoming scarcer, inputs (like irrigation, fertilizer, pesticides, mechanical operations and labour) began to be applied more intensively during the last three decades to increase agricultural production. The number of crops harvested per unit area in a year also increased in many countries. While global expansion of agricultural area has been modest in recent decades, intensification has grown rapidly (WRI). Even if yields continue to grow under these conditions, this does not necessarily indicate that agro-ecosystems are in good shape because increased inputs often mask the underlying soil degradation.

Area under irrigation grew from 153 million hectares in 1966 to 271 million hectares during the last three decades. Although the irrigated land forms just about 5.5 per cent of all agricultural land and 17.5 per cent of the cropland, yet irrigation is more extensive in some regions than in others. China and India together have nearly 41 per cent of global irrigated area while Western Europe and the USA hold additional 12.5 per cent. In marked contrast, the arid and semi-arid regions of Sub-Saharan Africa and Oceania (mostly Australia) contain only 3 per cent of the world's irrigated land.

Market-oriented irrigated agriculture tends to turn traditional subsistence but low-risk farming into high-risk commercial farming. In many developing countries like India, crop failures are not uncommon, pushing the farmers to face great hardships, particularly when inputs have been purchased on loans from money-lenders. Soil salinization, caused by poor irrigation management, and loss of soil fertility due to over-cultivation and imbalanced application of fertilizers further add to the problems of illiterate and resource-poor farmers. Absence of ownership rights, insecurity of land tenure and little direct access to market impose additional limitations to a losing proposition.

Economic Importance and Livelihoods

Agriculture is most important to the economies of low-income countries, accounting for nearly one-third of their Gross Domestic Product (GDP). This share is even more than 50 per cent in many parts of Sub-Saharan Africa. In the group of middle-income countries, contribution of agriculture to national GDP is around 12 to 25 per cent. GDP of high-income countries of North America and Western Europe, on the other hand, is remarkably dominated by other economic sectors and the contribution of agriculture is just 1 to 3 per cent, even though the value of the agricultural output in these countries represents 79 per cent of the real market value of world's total agricultural products (WRI).

It appears that the conventional measures of agriculture's share of GDP grossly underestimate agriculture's contribution to national economies. For example, agriculture's share in GDPs of the Philippines, Argentina and the United States is stated to be 21 per cent, 11 per cent and 1 per cent respectively but the total value of agriculture, including manufacturing and services further along the marketing chain, turns out to be 71 per cent, 39 per cent and 14 per cent of their total GDPs.

In addition to agro-ecosystems' contribution in terms of economic goods produced by them, they also provide employment to millions. Agricultural labour makes nearly 46 per cent of the global labour force. A comparison of the industrialized countries with developing ones in this respect brings out striking differences with obvious policy implications. In North America, just 2.4 per cent of the labour force is directly engaged in agriculture while this percentage is 56 to 65 in East, South and Southeast Asia and also in sub-Saharan Africa. Predominance of agricultural labour in most of the developing countries represents, in a way, the livelihood, employment, income and cultural heritage.

Human Nutrition and Food Security

Crop production appears at present to have the potential to continue to provide for adequate human nutrition. Globally, agro-ecosystems produce enough food that can provide every person on earth the minimum human nutrition of around 2700 k cal per day (FAO 2000). However, many people do not have adequate access to that food with the result that nearly 800 million people remain hungry and undernourished, most of them in Sub-Saharan Africa, the Caribbean and South Asia.

In case the global population rises to 7.5 billion people by 2020 as projected, the demand for cereals and meat is expected to grow by 40 per cent and 58 per cent respectively with 85 per cent of this increase coming from the developing countries. Also, the demand for roots and tubers is expected to grow 37 per cent, with 97 per cent of this increase coming from the developing world. Furthermore, if the poverty alleviation programmes make the expected headway, there will be an additional increase in demand for food as the poor and malnourished may like to use their enhanced income to buy food that they were not able to afford earlier.

Long-term capacity of agro-ecosystems depend primarily on natural processes and human management practices how they degrade, maintain, or improve soil health status, water availability (also quality) and nutrient balance. Agricultural productivity has already been greatly reduced in about 24 per cent of agricultural lands while additional 40 per cent are considered to be strongly and very strongly degraded (beyond rehabilitation). Most severely affected areas happen to be in South and Southeast Asia where populations are among the densest and agriculture most extensive (WRI). Soil nutrient balances are also reported to be negative in most crops and cropping systems in Latin America and the Caribbean indicating decline in soil fertility. Nutrient depletion is also widespread in Sub-Saharan Africa. Other areas, where the capacity of agro-ecosystems to produce food appears to be most threatened, ("Hot Spots") include northeast Brazil and sections of Argentina, Bolivia, Colombia and Paraguay.

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Soil degradation may have more immediate impact on the food supply in developing countries as agricultural productivity is estimated to have already declined significantly on around 16 per cent of their agricultural land, especially on cropland in Africa and Central America. Estimates show that about 74 per cent of Central America's agricultural land, 65 per cent of Africa's and 38 per cent of Asia are degraded and have reduced productivity (WRI).

The economic and social impacts of soil degradation have been far greater in developing countries than in the case of industrialized countries where decline in soil status is often masked by application of high levels of fertilizer and other inputs. In addition, their most important grain producing areas have deep and geologically young soils that can withstand considerable degradation without showing adverse effect on yield.

A striking feature of global agriculture is its focus on relatively few species. Only about 120 crops are economically important while more than 90 per cent of the caloric intake of world's human population comes from just 30 crops. This somewhat narrow base notwithstanding, there has traditionally been immense genetic diversity within these crop species, and this diversity, conserved and enhanced by farm families over the past ten centuries, has historically helped to maintain the productivity of agro-ecosystems and it is still a valuable reservoir of genetic material for modern plant breeding and also for the candidate genes manipulated through biotechnology and genetic engineering tools.

Crop genetic diversity is, however, on a decline today. Modern high yielding varieties are taking on more uniform characteristics, and these varieties are planted over large areas in monocultures. This tendency is not limited to high-income countries where the commercialization of agriculture is most prevalent. Modern superior crop varieties are displacing traditional varieties throughout the world, threatening the loss of an enormous genetic resource and increasing the vulnerability of large areas of homogeneous crops to incidence of virulent pests and disease epidemics. Across all developing countries, modern varieties were reportedly grown on 74 per cent of rice area in 1991, 74 per cent of wheat in 1994 and 60 per cent of maize in 1992 replacing the locally adapted cultivars.

2. Special Features of Agro-ecosystems in Developing Countries

- The earliest agro-ecosystems began developing around ten centuries ago in some areas that now happen to be in the developing world.
- The eight distinct Centers of Origin of Cultivated Plants, outlined by Vavilov and his team in 1920s, also occur in the developing countries. Putative progenitors and their closely related wild forms continue growing and evolving there constituting the valuable reservoir of genes for resistance to pathogens and pests and also for adaptation to abiotic stress environments.
- Genepool of plants picked up by early humans for their food security increased remarkably as the agriculture spread and farm families continued to conserve, enhance through continuous selections, share and exchange seed and propagation materials. This is reflected in the recognition of areas of crop diversity around the world, mostly in the developing countries. Their heritage of agricultural biodiversity and associated knowledge continued to evolve in the public domain for common good. The focus remained on food security and healthcare. Trade concerns developed much later. Ancient wisdom documented in old scripts, preserved in India among other centers of learning, considered agriculture occupation as the most respected by the society while trading came next to it. A glaring association between agro-biodiversity-richness and economic poverty is, however, visible at present around the globe reflecting the advantage of research and technology in adding value to crop genetic diversity.
- Agricultural research continues to be primarily in the public sector in the developing countries even at present and Farmers' Rights are widely respected with priority accorded to recognize them legally. This is in marked contrast to the paradigm shift to proprietary research linked to claims for intellectual property rights, often devoid of bio-

Box 2. On-farm Conservation of Agro-biodiversity

Genetic diversity in cultivated plants is important to farmers for reducing the risk of widespread incidence of diseases and pests damaging their crops. It is equally important to plant breeders and biotechnologists, whether working in public sector organizations or in biotechnology corporations, as it serves as the reservoir of genes for obtaining the target genes controlling the desired traits. It is also important to conserve this genetic diversity for use of future generations enabling them to meet their needs and also to face the unforeseen changes in climate and soil degradation or the sudden appearance of more virulent forms of pathogens and insect pests in coming years.

There are about half a million seed samples of different crops kept under long-term storage in gene banks of Future Harvest International Research Centres and placed under auspices and supervision of the FAO. More than twice this number is also stored in *ex situ* collections stored in national gene banks. While this kind of germplasm collection and storage in gene banks promotes their evaluation and utilization by breeders and other researchers, it also cuts off further evolutionary development of these materials. Notwithstanding the risks involved in storage, this approach of conservation requires frequent testing of these samples to check their viability and also their seed multiplication for replacement when the viability falls below a prescribed level. A less-expensive and nature-friendly method is being practiced by farmers over the past nearly ten thousand years to achieve the twin objectives of on-farm conservation and furthering the co-evolution of resistant genes in crop varieties. *In situ* on-farm conservation of agro-biodiversity is also the best way to maintain and promote traditional knowledge of the farming systems in which the farmers' varieties have evolved.

ethics and bio-safety considerations, as observed in some highly industrialized countries and also reflected in provisions of WTO-TRIPS agreement.

- Agriculture and related activities continue to remain the predominant sector for employment to growing populations in developing countries and the health and capacity of agro-ecosystems are of prime concern to them. Agriculture is contributing a large share to GDP of these countries but growth and investments in this sector are not rising as required to achieve sustainability. Operational holdings are small and getting smaller in most of these countries while land tenure is insecure and the reforms are overdue. Poor development of direct linkage to markets and on-location value-addition through post-harvest

Box 3: Farmers' Rights

Farmers' Rights were recognized by the FAO Council in its resolution 5/89, balancing thereby the Breeders' Rights approved vide resolution 4/89, as "rights arising from the past, present and future contribution of farmers in conserving, improving and making available plant genetic resources, particularly in the centers of origin/ diversity". Through an Annex of the International Understanding on Plant Genetic Resources (IU), parties agreed that Farmers' Rights would be recognized through an international fund.

How Farmers' Rights will be operationalized is of critical importance to the continuing on-farm (*in situ*) conservation of crop genetic resources. These rights have not been precisely defined but two perceptions have emerged, namely, interpreting them as a legal concept or considering them as a general political concept. The former envisages them an alternative form of intellectual property rights covering, for example, the products of farmers' selections and breeding effort while the latter considers them in the form of various entitlements expecting an international fund to finance crop genetic resources' concerns and relevant developmental work.

Unfortunately, the proposed international fund under the FAO has not yet been established. In the meantime, legal protection of Breeders' Rights is being pressed as an obligation under Article 27 (3b) of the TRIPS Agreement of the World Trade Organization. The 1978 version of the International Convention for the Protection of New Varieties of Plants (UPOV) allows a farmer to re-sow the seed harvested from protected varieties for his own use (farmers consider this as their "right" while some term it as a "privilege"). The 1991 version is more specific as it states that the discretion rests with national governments in deciding whether or not to uphold the Farmers' Rights while restricting the Breeders' Rights. It is also obvious that farmers' varieties would need to be sufficiently distinguishable and describable in order to be eligible for protection under the new Protection of Plant Varieties and Farmers' Rights; varieties that satisfy a stricter criterion qualifying for stronger and/ or longer protection.

processing are limiting factors to economic progress of farm families comprising the rural and tribal population.

- Farm families in developing countries have been practicing on-farm *in situ* conservation and enhancement of agricultural biodiversity through successive generations and their past and present contributions need legal recognition in the form of Farmers' Rights and also positive incentives at the local, national and global levels. Providing opportunities to rural farm families for increasing their income through generating off-farm jobs for them needs priority attention.

- Global food security and also the farmers' aspirations look towards synergistic linkage between public and private sectors with the strong support of international institutions and funding agencies to reap benefits from traditional good practices combined with advances in biotechnological research. This development is also expected to contribute significantly to efforts aimed at maintaining and promoting the health and capacity of agro-ecosystems.

3. Issues and Policy Implications

3.1 Production of Goods and Services by Agro-ecosystems

Agricultural ecosystems not only produce food and meet other basic requirements of human and livestock populations but they also serve as the backbone of national economies of most of the developing countries and also function as major driving force propelling global market systems creating demands and purchasing power. Around 45 per cent of the world's human population and nearly 46 per cent of the global labour force are directly linked to agriculture. Keen interest and increasing concerns about agro-eco-systems notwithstanding, national policy makers find it increasingly difficult to identify the issues involved and to fully appreciate their policy implications. This section attempts to capture WRI's major findings and identify the issues and their policy implications from the developing country perspective.

3.2 Pressures/ Threats faced by Agro-ecosystems and Policy Responses

Both the condition and the capacity of an ecosystem are strongly influenced by its location and its dominant physical characteristics. Since agro-ecosystems arose through conversion by humans to serve their needs, they

Major Findings	Issues	Policy Implications
Food Production:		
Food production is likely to continue rising for some more time but it already faces constraints and severe regional imbalances.	• Sustainability of The use of natural Resources:	Developing National Policy on sustainable use of natural resources.
	- Assessment of sustainability	Developing suitable indicators in national/ local context and promoting their use.
	• Increasing soil degradation	Developing National Land Use Policy.
	- Soil erosion	Promoting soil conservation measures.
	- Water logging	Linking irrigation with adequate drainage.
	- Soil salinity/Alkalinity	Improving water management and adopting reclamation measures based on salt tolerant crops and trees, soil amendments and leaching where feasible.
	• Decreasing water availability and quality - Increasing sectoral competition for water use	Developing National Water Policy with long-term perspective and preparing medium and long-term action plans.
	- Receding groundwater level in many areas	Encouraging appropriate cropping schemes and crop rotations.
	- Excessive use of chemical fertilizers and pesticides	Promoting soil-test based application of fertilizers and integrated pest and nutrient management.

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	• Shrinking agro-biodiversity	Reducing dependence on one or a few crops/ varieties/ crop rotations and promote market-linked diversification of farming systems.
	• Changing climate and atmospheric carbon	Improving data collection, analysis and modelling techniques. Making advance preparations by increasing resilience in agro-ecosystems and developing suitable options
Projected Food Demands:		
Global population is projected to rise to 7.5 billion by 2020. Demand for cereals and meat is expected to grow by 40 per cent and 58 per cent respectively with 85 per cent increase coming from the developing countries. Likewise, the demand for roots and tubers is expected to grow by 37 per cent with 97 per cent of this increase coming from the developing world.	• Improving productivity	Increasing budgetary support to Natural Resource Management. Increasing focus on research and provide more funds.
	• Intensification of production system	Developing further the 'Green Revolution', that has been achieved by many developing countries in several cereal crops, into a sustainable 'Ever Green Revolution' by adopting the emerging new innovative technologies and covering more crops. Negotiating transfer of new technologies from the developed countries and corporate sector. Developing post-harvest technology, storage facilities, processing and market linkages.

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		Promoting diversified farming systems with economically feasible and socially acceptable incentives.
Intensification:		
While the global expansion of area under agriculture has been modest during the past three decades, intensification has grown rapidly.	Sustainability of the agricultural production systems	Developing National Agricultural Policy with long term perspective and action plans.
	• Sustainable use of natural renewable base resources	Promote integrated nutrient and pest management.
		Encouraging appropriate cropping systems and diversified crop rotations.
		Improving use-efficiency of inputs.
	• Containing adverse impact on other ecosystems	Focus on better water management practices and conjunctive use of water resources.
		Supporting green manuring and other practices for increasing organic carbon content of soils.
		Promoting application of high technological innovations to boost productivity and stabilize agricultural production.
		Ensuring availability and affordable costs of non-renewable purchased inputs.
		Developing intensification technologies for the benefit of resource-poor farmers with small operational holdings.

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		Providing insurance cover to protect small farmers against high risks involved in high-inputs technology.
		Supporting diversified farming systems.
		Developing Village Knowledge & Service Centres based on single-window delivery.
Irrigated Agriculture:		
Out of the global cropped area under irrigation, 41 per cent lies in China and India, 12.5 per cent in Western Europe and USA, but only 3 per cent in arid and semi-arid regions of Sub-Saharan Africa and Australia.	• Improved water management	Providing more investment in research on irrigated agriculture with a focus on developing new innovative technologies.
	• Improved water management	Reducing water conveyance losses.
	• Higher water-use efficiency	Promoting conjunctive use of all water resources.
	• Better soil healthcare	Supporting better cropping systems and diversified farming.
	• More productivity	Ensuring that irrigation must be accompanied by adequate drainage system.
	• Minimising adverse impacts	Providing soil testing facilities and soil healthcare service.
		Developing indicators for monitoring of adverse impacts and be prepared with land reclamation technologies where needed.

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		Encouraging farmers to manage their irrigation water resources themselves by forming Village Water Cooperatives and Self-Help Groups.

National Gross Domestic Product:

Agriculture's contribution To national GDPs is more than 50 per cent in many parts of Sub-Saharan Africa, one-third in other low-income countries, 12 to 25 per cent in middle-income countries but just 1 to 3 per cent in high-income countries of North America and Western Europe.	• Agriculture-based economic development in low- and middle-income developing countries	Developing National Agriculture Policy and lobbying for higher investment in agriculture. According status of industry to agriculture. Providing more budgetary funds for research and extension in public sector plans. Developing promotional schemes for agro-products and provide incentives to entrepreneurs. Promoting public and private sector collaboration for greater investment in agriculture. Promoting agro-based cottage processing and manufacturing industries in rural areas. Developing quality control of agricultural produce and products. Expanding internal and export markets for agricultural produce and products. Negotiating with developed countries to get greater market access for agriculture under WTO.

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Dependence of People:		
The developing countries have nearly 65 per cent of the global area under agro-ecosystems, and Asia alone has over 70 per cent of the people living in or around these ecosystems. Agriculture engages 46 per cent of the global labour force While this percentage is 56 to 65 in East, South and Southeast Asia and also in Sub-Saharan Africa, it is just near 2 per cent in North America.	• Vital role of agriculture in national income generation and human welfare	Developing national strategy for agricultural development and preparing perspective long-term and medium-term action plans with provision of adequate funds for proper implementation.
	• Agriculture-based planning and model for economic development	Increasing investment in research to increase productivity per unit area and per unit time.
	• Increasing population pressure and decreasing per capita agricultural area	Negotiating to obtain new technologies and make their best use to enhance productivity and stabilize production gains.
	Increasing demand for food and other agricultural produce	Involving local people in technology assessment employing participatory rapid appraisal techniques
Area under agriculture remained almost unchanged in South Asia during the last 30 years but increased substantially in West Asia and Brazil while it decreased remarkably in developed countries.	• Food and Nutrition Security	Generating more employment in rural areas and provide opportunities to farm families to earn additional income to meet their basic needs.
	• Livelihood Security	Providing scientific back up to indigenous knowledge of farm communities and making use of the prevailing good practices.
	• Focus on basic needs for farm families and other farm workers	Promoting processing of agricultural produce and agro-based manufacturing cottage industries in rural areas to add value to the produce and providing more off-farm employment and livelihood security to farm families.

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	- Use and protection of indigenous knowledge	Strengthening Food-for-Work rural development programmes to facilitate access of poor people to food and nutrition.
	- Documentation of case studies on good practices	Giving legal recognition to Farmers' Rights and operationalise them as human rights to support on-farm *in situ* conservation of agricultural biodiversity.

share some basic features with their original natural ecosystems from which they arose. They are also highly diverse in terms of soils, topography, climate, rainfall, crops and livestock and also in culture of the people living in them and their income levels from agriculture/livestock. It is, hence, more appropriate to identify pressures/threats and assess policy responses based on different categories of these ecosystems.

4. Conclusions

4.1 Diversity of Agro-ecosystems and their Significance

A notable feature of agro-ecosystems is their diversity in terms of their natural base resources (including soil, water, nutrients, crop plants and

Issues	Policy Responses in Developing Countries
Rainfed Agro-ecosystems	
- Instability in biological productivity caused essentially by the aberrant weather	Focusing on watershed management system considering that water is the foremost critical factor in rainfed farming and rain is the only source of water, directly and through recharging of the groundwater.

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• Wide range in rainfed production systems and uncertain water availability	Strengthening traditional soil and water conservation practices and fine-tuning them with scientific back-up since case studies have shown that water availability is not a serious constraint if rainwater is managed properly.
• Increasing human and livestock pressure	Promoting research through developing inter-disciplinary and multi-institutional consortia based on appropriate linkages and people's participation.
• Continued decline in soil organic matter due to poor biomass production and inadequate integration of crop and livestock farming	Adopting area-based planning with a focus on the irrigated production system as a whole rather than on individual crops or livestock to boost economy.
• Decline in agro-biological diversity	Developing and using suitable indicators for technology assessment promoting participatory rapid appraisal techniques and involving local people to draw upon indigenous traditional knowledge.
	Promoting integrated nutrient and pest management programmes and also providing proper healthcare for the livestock.
	Encouraging ecologically sound cropping patterns and diversified farming systems.
	Where the annual rainfall exceeds 1150 mm, giving attention to paddy and plantation crops.
	Promoting intercropping and also aquaculture under 750-1150 mm rainfall conditions and employing tubewell protective irrigation while ensuring the recharging process of groundwater.

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	Increasing emphasis on oilseeds and legume-based cropping systems and arid horticulture (with drip irrigation) under 500-750 mm rainfall conditions. Supporting arable farming linked to animal husbandry and rangeland management where average annual rainfall is below 500 mm. Providing strong support and incentives to promote on-farm *in situ* conservation of agro-biodiversity with proper back-up *ex situ* conservation in gene banks. Giving priority to poverty alleviation programmes and Food-for-Work projects.
Arid Agro-ecosystems	
• Growing human and livestock population pressures	Providing greater support to research and technology development.
• Chronic water shortages and weather aberrations	Promoting 'Composite Mapping' by using database on the status of renewable natural resources, land use and soil degradation status.
• High vulnerability of soils to wind erosion, weather aberrations, salinity and sodicity in soils and groundwater, low water retention capacity of soils, high infiltration rate, poor structure and crusting of soils with low organic matter content and available phosphorus, low nutrient buffering capacity of soils particularly the micro-nutrients.	Improving and promoting traditional water harvesting and under-ground storage methods under less than 200 mm rainfall conditions. Improving technology for dry land cropping including proper moisture conservation, suitable planting methods, mixed and strip cropping and use of drought and salt tolerant crops and varieties. Upgrading silvi-pastoral system, agro-forestry and rangeland management to meet the growing animal grazing needs.

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• Intensive irrigated cropping in canal command areas with inadequate drainage	Promoting arid horticulture, where feasible, based on sprinkler and drip irrigation systems.
• Irrigation with saline/ brackish waters	Encouraging integrated nutrient management in dryland farming under canal irrigation or brackish water situations.
• Use of heavy machinery for farm operations, particularly on marginal lands	Providing support to reclamation of degraded lands by using soil amendments combined with land shaping, rainwater harvesting, soil profile modification, more suitable planting techniques and salt tolerant crops and their varieties.
• Growing desertification processes	Strongly supporting the programmes on sand stabilization using suitable plant species, erecting wind breaks, developing shelter belts and involving local people.
	Promoting participatory crop improvement and technology assessment programmes involving local people in decision-making.
	Monitoring the spread of desertification using satellite imageries and GIS techniques and adopting preventive strategy and action-plan.
	Adopting poverty alleviation projects developing more skills, generating additional income to farm families and promoting Food-for Work programmes.
Irrigated Agro-ecosystems	
• Long term sustainability of agricultural production systems	Supporting research on cropping and farming systems best suited to diverse soil, water and climatic situations of irrigated ecosystems.
• Depletion in soil fertility and decline in productivity	For the areas having limited water availability, focusing on crop diversification and on development of management practices for diversified farming systems.

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• Decreasing biodiversity and increasing genetic uniformity in crops	Promoting diversification of farming systems, crops and their varieties to avoid increase in genetic vulnerability to widespread epidemics of diseases and pests.
• Soil salinity/alkalinity and water-logging	Supporting studies on different kinds of physical and chemical degradation of soils due to intensified agriculture coupled with indiscriminate use of irrigation water and non-judicious fertilizer application in irrigated areas.
• Poor water and nutrient management practices	Providing adequate drainage in irrigated areas. Where natural drainage is impeded, promoting more efficient pressurized water management techniques like sprinklers and drip irrigation.
• Excessive use of chemical inputs	Adopting land reclamation measures including the use of soil amendments, leaching and salt-tolerant crops and varieties.
• Over-exploitation of groundwater leading to rapid lowering of water table	Increasing the water use efficiency and promoting conjunctive use of rainfall, surface water and groundwater to maintain hydrological balance and avoid over-exploitation of groundwater.
• Use of poor quality waters for irrigation	Promoting integrated nutrient and pest management schemes, application of fertilizers based on proper soil testing results and scheduling of irrigation based on water requirements of different crops.
	Discouraging cultivation of high water requiring crops like sugarcane and paddy in areas using brackish water for irrigation.
	Promoting the best suited cropping schemes and crop rotations to prevent heavy withdrawal of nutrients due to exhausting cropping schemes and inadequate replenishment of nutrients, particularly micronutrients.

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Hilly and Mountainous Agro-ecosystems	
• Natural instability and ecological fragility	More investment in research and appropriate technology development with a focus on proper watershed management.
• Increasing population and tourists pressure	Developing location/area specific technologies and adopting soil and water conservation techniques like contour bunding and bench terracing combined with improved agronomic practices.
• Inaccessibility, poor infrastructure and undeveloped market links	Promoting diversified and integrated farming systems incorporating food crops, vegetables, horticulture, commercial crops, floriculture, plantation crops, agro-forestry, livestock farming and silvi-pastoral system.
• Cultivation on sloping land with high risk of soil erosion and water loss	Promoting cultivation of high value and low volume crops like fruits, medicinal plants, spices, ornamentals and plantation crops.
• Unplanned shifting cultivation practices	Supporting minor irrigation and water saving techniques like sprinklers and drip system.
• Decreasing diversity in farming systems	Developing post-harvest technology including processing and product-manufacturing units with adequate storage facilities for perishable produce like milk, cut-flowers and vegetables.
• Land use conversion	Supporting development of suitable agricultural implements and machinery, like small-sized power tillers, with particular attention to the small operational holdings.
• Inadequate forest management systems	Providing simplified credit support and crop insurance cover for stepping up the use of inputs and adoption of modern technology.

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	Encouraging replacement the ‘shifting cultivation’ practice by promoting integrated horti-agricultural systems and providing additional income opportunities.
Coastal Agro-ecosystems	
• Ecological fragility	Developing and adopting eco-friendly technologies.
• Land use conversion	Providing protection to mangrove vegetation and associated biodiversity.
• Poverty and illiteracy	Regulating land use in coastal zones.
• Negative impact of anthropogenic pressure	Promoting off-farm additional income generation schemes for resource-poor farm families ensuring gender sensitivity.
• Climate change	Focusing on improving literacy, healthcare and developing additional skills.
• Uncertainty to the lives and properties, particularly those in lowlands, due to high tidal floods and cyclones	Promoting livestock and aquaculture-based diversified agricultural systems.
• Rapidly increasing municipal wastes, industrial effluents and domestic residues	Developing Village Knowledge Centres Network, with the help of Self-Help Groups, linked to weather forecasting and early warning systems.
	Aiding the construction of protective embankments with wind-breaks and shelter belts.
	Improving drainage not only to assist flood control but also to meet agricultural requirements through internal field drainage.
	Supporting on-farm reservoir for rainwater storage.
	Promoting integrated agri-horticultural systems including vegetables, plantation crops and aquaculture while managing salinity and growing salt-resistant varieties.

livestock), management practices, productivity levels, human culture and associated indigenous traditional knowledge. Their diversity is also largely because of their adaptations to varying environments of specific locations and their responses to management practices of farming communities through successive generations. Based mainly on agro-climatic factors including water availability for seasonal raising of different crops, they can be categorized into five sub-groups (namely, rainfed, arid, irrigated, hilly & mountainous and coastal agro-ecosystems), each having some distinct common characteristics while still remaining diverse for other features. Diversity within and among agro-ecosystems is essential for their efficient functioning, for maximum production making the best use of available natural base resources and for their buffering elasticity to successfully meet the unforeseen environmental demands in future.

Ever growing demand for food and other agricultural products has led to rapid developments in farming practices and remarkable increases in crop production worldwide. Besides the farmers' vital role in achieving this success, other contributory factors included the expansion of land area under cultivation, development of farm machinery and improved agronomic practices, increased intensity of cropping based on additional irrigation facilities, and, more importantly, the adoption of high yielding crop varieties combined with greater use of fertilizers and pesticides. Although food production at the global level has kept pace with the rise in human population so far, yet the unmistakable signs of decline are now clearly visible in many areas regarding the health and capacity of these systems as shown by the WRI Report. There are regional differences and imbalances calling for urgent attention of the policy makers, planners and managers around the globe.

Globally, agro-ecosystems produce enough food that can provide every person on the Earth the minimum human nutrition requirement of around 2700 kcal per person each day (FAO 2000). However, many people do not have adequate economic access to that food with the result that nearly 800 million people remain hungry and undernourished, most of them in Sub-

Box 4. Farmers' Livelihood Security

Multilateral agreement under the World Trade Organisation (WTO) contains a series of interlocking agreements whose provisions set out the rules governing the international trade. Its non-discrimination rules forbid the member states to treat the foreign products less favourably than domestic 'like products' or from treating the products imported from one member state less favourably than like products from another member. Its Article XI prohibits quantitative restrictions (QRs), like quotas or bans, on imports or exports with certain specified exemptions.

India joined the WTO on 1st January 1995 accepting obligatory structural adjustments. Six separate complaints, including one of the United States, were lodged against India with the WTO Dispute Settlement Body in 1997 alleging continued application of QRs on imports. With its heavy dependence on agriculture and small industries that sustained mass employment and contributed significantly to national Gross Domestic Product (GDP), India was among the nations that were resorting to protection through QRs. Following negotiations, an agreed schedule for removing all the QRs by 1st April 2001 was formally notified by India to the WTO. This commitment was met by India by removing QRs on the remaining 715 commodities on that date. Removal of QRs raised the public concerns apprehending that the WTO regime was skewed in its application against the interests of the developing countries.

Indian economy is essentially agriculture-based and this sector directly engages about 64 per cent of the labour force. It also contributes nearly 26 per cent of GDP and about 18 per cent of the total value of the country's exports. Its role is particularly important since it is source of livelihood to over 700 million people with total dependence of farm families (and also the landless labour) managing 1,066 million operational farm holdings.

Removal of QRs and consequent likely spurt in import of food items may pose a serious threat to the livelihood of farm families and associated farm labour. It is being pleaded that protection of livelihood of farmers in agro-based developing economies needs to be treated as the basic human right and this right should be specifically protected under the WTO rules in recognition of the unique contributions of farmers towards developing, enhancing and on-farm conserving the agricultural biodiversity. One way of doing this may be to introduce a **"Livelihood Security" Box** in the provisions of the WTO giving an option to developing countries like India, China and others to deny import of food items to provide livelihood security to farmers.

Saharan Africa, the Caribbean and South Asia. In case the global population rises to 7.5 billion as projected for the year 2020, the demand for cereals, meat and roots(and tubers) is expected to grow by 40, 58 and 37 per cent respectively, with over 85 per cent of this increase coming from the developing countries. Furthermore, if the on-going poverty alleviation programmes make the expected headway, there will be an additional increase in demand for food as the poor and undernourished may like to use their enhanced income to buy food that they were not able to afford earlier.

Agricultural productivity has already been greatly reduced in about one-fourth of agricultural lands and most of these areas happen to be in South and Southeast Asia, where human populations are among the densest and agriculture most extensive (WRI). Other areas where the capacity of agro-ecosystems to produce food appears to be most threatened ("Hot Spots") include Sub-Saharan Africa, Northeast Brazil and sections of Argentina, Bolivia, Colombia and Paraguay. The economic and social impacts of soil degradation are expected to have more adverse impact on the food supply in developing countries as compared to the industrialized countries, where the soils in most areas are deep and young and the decline in soil status is often masked by the application of high levels of fertilizer and other chemical inputs.

Another disturbing feature of the global agriculture is its focus is on only about 120 economically important crops, with more than 90 per cent of the caloric intake of world's human population coming from just 30 plant species. Crop genetic diversity is on further decline today as modern high yielding varieties are taking on more uniform characteristics and these are planted over large areas in monocultures replacing the genetically diverse and locally adapted cultivars grown traditionally in developing countries. Across all developing countries, modern varieties were reportedly grown on 74 per cent of rice area in 1991, 74 per cent of wheat in 1994 and 60 per cent of maize in 1992, replacing the local seed materials.

4.2 Sustainable Agriculture with Sustainable Development: The Way Forward

Intensive irrigated agriculture, with high chemical input use and unsustainable crop rotations, has thrown up problems in some areas in the form of soil degradation, water logging, salinity, disturbed hydrological cycle, pollution, nutrient imbalances, biodiversity loss and high vulnerability to new diseases and pests. Agriculture has received more attention in recent years not only for its contributions to global food and nutrition security and providing sustenance and employment to nearly half of the human population, but also for its important role in international trade and because of its adverse impact on environment.

Several organizations have commissioned comprehensive studies on assessment of the status and sustainability of ecosystems, including agro-ecosystems, on a global scale. Their approach and methodologies differ but their results show alarming deterioration. The World Resources 2000-2001 report, using findings of a Pilot Analysis of Global Ecosystems, presented a scenario showing clearly declining trends in five major ecosystems but also pointed to striking regional differences. A more comprehensive Millennium Ecosystem Assessment by UNEP is underway.

Another kind of attempt is being made by WWF in collaboration with UNEP and WCMC by bringing out Living Planet Reports measuring the world's natural wealth in forests, freshwaters and coastal and marine areas based on changes in populations of selected indicator species for computing Living Planet Index. This report for 2000 has an additional feature in the form of the "Ecological Footprint" that measures a population's consumption of food, other materials and energy in terms of the area of the biologically active land or sea required to produce those resources and to absorb the corresponding waste. Interestingly, it shows among other things that the "Cropland Footprint" (a measure of the area required for an individual to produce all the quantities of crops which that individual consumes) of a person living in North America or Western Europe is more than twice of that of an individual residing in Latin America, Asia/Pacific or Africa from where most of the world's hungry and undernourished people have been reported (WWF 2000).

Leaders from 185 countries pledged during the World Food summit, held in Rome in 1996, to work towards eradicating hunger. Follow up meeting, World Food Summit: Five Years Later, is scheduled to be held in Rome in November 2001 to review the progress made towards the goal of reducing the number of hungry people by half by 2015 and consider ways to accelerate the process. Unfortunately, current data indicate that the number of under-nourished is falling at a rate of 8 million each year, far below the average rate of 20 millions per year required to reach the target. Although a headway has been made yet much remains to be done. The message is clear that ways and means need to be found for raising the productivity of agro-ecosystems substantially and faster, in an ecologically sustainable manner, and economic access to food of the hungry people will have to be increased. This calls for developing strategies and action plans for promoting sustainable agriculture with sustainable development in developing countries with agriculture-based economies.

4.3 Win – Win Options

Lack of adequate and sustained funding has slowed down agricultural development in many developing countries whose national economies largely depend upon agricultural production. Financial institutions tend to invest in areas with assured environment (like irrigated agriculture) expecting that it will generate more agricultural output and higher economic growth at lower cost than in areas under stress and uncertain environments (like rainfed and arid agriculture). Such investment is also seen to help in poverty alleviation since a faster economic growth may provide more employment opportunities with higher wages while more agricultural production may lower food prices, both the outcomes being beneficial to the poor. People living in areas under stress environments should also benefit from these developments that seem to assist in availability of cheaper food, offering increased market opportunities for growth, and also opening new options to underemployed agricultural workers to migrate to more remunerative jobs in intensive agricultural areas. Arguably, this migration may also decrease environmental degradation because of reduced population pressure in stressed areas that are likely to benefit additionally from the migrants sending remittances back home.

This model for economic development has received a setback from recent experiences in India (and also China) showing that the right kind of investments in semi-arid rainfed areas can increase agricultural productivity in diversified farming systems to much higher levels than previously expected and may compare well in gains from comparable investments in irrigated areas that have reached the point of diminishing returns. There are numerous such situations under the wide spectrum of rainfed agro-ecosystems that offer 'win-win' options, that is, higher growth ensuring economic security, greater poverty alleviation and lower environmental degradation meaning higher aggregate social returns. When resource-poor farmers in developing countries are being motivated to go for new technologies and adopt high-cost (purchased inputs) and high-risk crop production packages, it is time for the international financial institutions to reconsider their priorities and eligibilities for investments in agricultural development, particularly with the objective of poverty alleviation and supporting eco-friendly and integrated management systems of natural resources.

It is now widely recognized that countries and regions that are currently exporting food and other agricultural produce need to assess sustainability of their production levels and identify "Hotspot Areas" that require priority attention. Suitable criteria/ indicators for the desired assessment need to be developed to begin with and the analysis must lead to the development of a budgeted action plan along with supportive recommendations on policy, administrative and other regulatory measures. It is not intended to suggest a universal model or some ready-made solutions for adoption. Developing suitable options and sharing the lessons learned from such process may be more helpful. A study conducted recently on food insecurity in rural India, for example, inferred that every state had its own strengths and weaknesses in relation to achieving the goal of sustainable food security and, hence, required different action plans for this purpose (MSSRF and WFP, 2001).

4.4 Policy Recommendations:

While recognizing the limitations in making general policy recommendations regarding agro-ecosystems due primarily to their highly diverse nature, some strategies are being suggested with a view to providing some options for the policy makers and managers working in agriculture-based developing economies. It is obvious that the priorities and follow up action plans will depend upon national policies and planning processes that respond to specific development (and also environment) needs and people's aspirations.

Strategy 1: Promoting high productivity and sustainability of agricultural production systems

- Defending the location-specific gains already achieved under different categories of agro-ecosystems by paying more attention to conservation and enhancement of soil and water resources, forests, biodiversity and other basic life-support systems.
- Extending the gains made under irrigated agriculture to rain-fed, semi-arid, hilly and coastal areas by adopting new yield enhancement and stabilization technologies and opting for low water requiring but high value crops.
- Making new gains through farming systems' intensification, diversification and value addition by making full use of the results obtained from molecular biology and innovative bio-technologies by forging new partnership with industry.
- Providing users-driven institutional support and centralized services to small and marginal farm families for adopting eco-farming based on integrated pest management, efficient water management, integrated nutrient supply, post-harvest technology and marketing access.
- Strengthening research on farming systems and diversified cropping schemes.

- (Crops, horticulture, livestock, aqua-culture and agro-forestry).
- Bridging the gap between the actual and potential yield levels (already achieved on research farms and demonstration plots) under major farming systems.
- Promoting the use of safer chemicals, in particular the pesticides, by regulating the production, import, export, disposal and use of Persistent Organic Pollutants, as recommended by The Stockholm Convention on POPs signed by 91 countries on 22-23 May 2001).

Strategy 2: Assigning top priority to land care and management systems

- Conserving prime farmland for agriculture by protecting them from conversion to other uses, often for short-term gains.
- Preventing the loss of the biological potential of the soil (desertification) by taking effective measures to check different kind of soil erosion.
- Restoring the degraded land by providing incentives, based on agro-forestry and other arable practices.
- Implementing land reforms to overcome land-tenure insecurity.

Strategy 3: Treating water as a social/public resource

- Developing strong public policy for regulation of water use (The model adopted by Israel may serve as a model for promoting irrigation with mixed sewage waters).
- Improving traditional rainwater harvest and underground storage methods.
- Promoting ecologically sound cropping patterns based on eco-zoning of crops.
- Supporting sprinkler and drip irrigation to improve water use efficiency.
- Adopting conjunctive use of surface and ground waters for irrigation (ensuring thereby more crop for every drop).
- Providing incentives for recycling of rainwater and home-used (waste) waters by developing and enforcing building bylaws for compulsory provision for this purpose.

Strategy 5: Strengthening conservation of living aquatic resources

- Regulating the land use in coastal areas by enforcing suitable policy, administrative and legislative measures.
- Promoting aquaculture-based diversified farming systems.
- Providing off-farm additional income opportunities to farm families with attention to gender sensitivity.

Strategy 6: Supporting on-farm conservation of agro-biodiversity

- Providing effective incentives to farming communities to support the *in situ* on-farm conservation of agro-biodiversity.
- Providing legal recognition to Farmers' Rights including their livelihoods security under WTO's Agreements on Agriculture and TRIPs (See Box 4).

Strategy 7: Developing the protocol on agro-biodiversity under CBD

- Expanding the Multi-lateral System of Exchange of Food Security Crops under the International Treaty on Plant Genetic Resources for Food and Agriculture.
- Enacting legislation (to be done by both the developed and the developing countries) supportive of access to genetic resources linked to equitable benefit-sharing and bring the private sector and industry under its purview.

Strategy 8: Supporting anticipatory research to face consequences of climate change

- Assisting on-farm *in situ* conservation of agro-biodiversity and long-term preservation of *ex situ* collections kept in Gene Banks for possible tapping of this reservoir of genes for enhancing plant adaptation to future climatic changes.
- Funding systematic world-wide research on avoidance and mitigation measures to face consequences of projected climatic changes.
- Expediting the pace of implementation of the Kyoto and Montreal Protocols through inter-governmental negotiations.

To sum up, sustainable development and integrated management of agro-ecosystems hold the key to economic development and well being of people in low-income developing countries where agriculture continues to employ more than half of the population. The developed countries are presently more concerned with food safety, industrialized large-scale farming and livestock production, agricultural trade issues, genetic engineering, environmental conservation, organic farming and diet-related obesity and health problems. In marked contrast, most of the developing countries worry about hunger, under-nutrition, rural poverty, low productivity in agriculture, inadequate infrastructure and market access.

Policy responses in developing countries for management and use of land, water and biological resources are increasingly taking note of ecological aspects and marketability criteria. Poverty alleviation, equity and ethics in the use of natural resources continue to dominate these policies but the sustainability aspect has not received its due attention as yet in most cases. Implementation of policies and experiences in this context vary a great deal among the developing countries and so do the level of economic development and the index of human development.

Future research efforts should aim at developing eco-technologies that blend traditional and frontier technologies. Participatory multi-stakeholder management of natural resources should provide a "win-win" situation for all, while offering all-inclusive (not exclusive) use and equitable sharing of benefits. Under protection of intellectual property, there should be a provision for compulsory licensing of rights (with justified reasoning) in case of discoveries that are of importance to human food, health security and ecological security (for example, discoveries that may help in combating the alien invasive species). The developing countries, whose national economies are primarily based on agriculture, are now vigorously lobbying for a level playing field for negotiations under the WTO's Agreement on Agriculture while asking for the protection of food security and also addressing the farmers' livelihood concerns.

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Debate on Intellectual Property Rights

Klaus M. Leisinger*

No one in a society is responsible for everything, no one has sweeping rights and no one is beholden for all the duties of society. Experience shows that a nation's economic and societal success is greatest if there is both a clear division of labour and responsibility between the different members of civil society and a common understanding with regard to shared values and the overall goals of society – including a fair equilibrium of duties and rights. Private sector corporations have specific and fairly clearly defined "duties and responsibilities" in society's division of labour. These are:

To provide goods and services that succeed in meeting effective customer demands can be sold at prices that are competitive and in the best interest of the corporation. The goods and services that are sold provide society with different kinds of value added – in the case of pharmaceuticals, they prevent premature death and disability, accelerate cure or alleviate the symptoms of diseases for which there is so far no cure. Being a successful pharmaceutical corporation therefore not only means being profitable, but also raising the quality of life of sick people, avoiding costly hospitalisation, and allowing people to go back to normal working lives instead of being bed-ridden.

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It is not only the right of a corporation to strive to be as profitable as possible; I firmly believe that it is part of its social responsibility and its duty within the framework of its corporate citizenship to be as profitable as possible – however, in the context of the "triple bottom line", i.e. also striving for social and ecological excellence. Sustained profitability resulting from sustained competitiveness on global markets is the precondition for a corporation to assume sustained responsibility towards society as a whole – i.e. to be a good corporate citizen.

The specific responsibilities of a corporation differ for those of other actors in the same society, e.g. the state, trade unions, NGOs or the church. In a perfect world, every individual actor in civil society contributes to the common good by fulfilling its specific core responsibility in the best and most cost-effective manner – the synergies created by the division of labour and specialisation allow for the highest level of national welfare.

1. The Role of the Pharmaceutical Industry

The pharmaceutical industry has recently been put under significant criticism for allegedly placing the sanctity of patents above that of life. *The Wall Street Journal* even referred to the industry as the pariah du jour. At such a time, it is important to recall that the basic role of industry is drug discovery and development, and the intellectual property rights on medicines is the foundation on, which drug research is built.

Vaccine and pharmaceutical products make a vital contribution to health and are central to any health system. They save lives, relieve pain, and cure and prevent disease. Modern drugs have contributed to the increased life expectancy of people, particularly in the industrialised world as well as in affluent sections in developing countries, with less suffering and hospitalisation as well as lower rates of almost every major disease. Medicines add years to life, improve the quality of life for patients, and generate substantial savings in terms of social and economic costs.

The key role for the pharmaceutical industry is to discover, develop, produce, and market innovative products to cure diseases, to ease suffering, and to enhance the quality of life. Single companies in the industry invest several billion dollars every year in research and development that has led to new, more effective treatments for many conditions. Although newer drugs cost more than those they supplant, their improved efficacy and better side effect profile often renders them more cost-effective due to overall savings generated (e.g., avoiding or reducing hospitalisation or surgery).

In view of the substantial investments of time and capital to bring a drug to market, as well as the high risk of failure, the research efforts of the pharmaceutical industry are primarily focused on diseases with potential for an adequate return on investment.

As less than 10 per cent of global spending on research is devoted to 90 per cent of the world's health problems, new mechanisms are urgently needed to finance research for treatments of diseases of poverty. A combination of market-based incentives, public-based mechanisms, and public-private partnerships are needed due to the large diversity in diseases of poverty. Some diseases could provide a marginal profit (e.g., malaria, tuberculosis) whereas others are likely to provide none (e.g., African trypanosomiasis). "Push" mechanisms aim to reduce the total research costs or risks of development through financial subsidies, grants, tax credits, protocol assistance, accelerated approval, etc. "Pull" interventions serve as financial incentives such as guaranteed purchase funds to compensate for the low- or no-profit market or subsidised sales and thereby reduce the financial risk for pharmaceutical companies.

2. The Importance of Intellectual Property Rights

Drug innovation is an expensive, lengthy, and risky process. It costs around US$600 million to develop a new drug. Only 5 in 5000 compounds that enter preclinical testing make it to human testing and only one of these gains regulatory approval. It takes an average of 10-12 years to bring a new drug to market, which provides an effective patent protect on of about 8-10 years. In the absence of patent protection, the successful drugs can readily be copied and marketed by companies who have made little investment and taken none of the risk.

Intellectual property rights are the lifeline of the research-based pharmaceutical industry. They enshrine the right of companies to have a chance of recovering their investment and to have a return of capital sufficient to ensure shareholder interest. The period of market exclusivity provided by effective intellectual property protection is essential for companies to sustain the vast and risky research and development investment necessary to provide new medicines and therapies. Without patents, the great majority of the treatments available today would not exist.

Patents have attracted much of the blame for the gap between rich and poor countries in access to medicines. The problems of patent protection in developing countries are exaggerated, in as much as about 95 per cent of the drugs on WHO's model list of essential drugs are available off-patent. These represent a wide range of drugs to respond to most disease conditions in developing countries, but a third of the world's population has no access even to these drugs. For diseases such as HIV/AIDS and drug-resistant forms of TB, new solutions need to be found that involve all actors in civil society – one of the concepts to be used here are "Private-Public-Partnerships". Within such partnerships, the "soft" handling of IP issues could become a potential contribution; differential pricing is another pathway between partner acting in good faith.

The Trade Related Aspects on Intellectual Property Rights (TRIPs) Agreement provides the framework for such solutions as it rewards research and innovation to provide treatment cures, but offers countries the flexibility to craft their domestic patent legislation in a way that also protects them during national emergencies (e.g., the HIV/AIDS crisis). Critics write as if the TRIPs Agreement has suddenly had a major effect on access to treatments in developing and least developed countries. The fact is that many developing countries are only now bringing domestic law into compliance with TRIPs Agreement and the least developed countries have until 2005 to amend their domestic policies.

But the discussion about intellectual property rights is a much more comprehensive one: Legal aspects are clearly important, but the development in the European debate on Green Biotechnology has shown, that ethical and moral issues play an important role as well. The debate has also shown that the right to make use of patents depends to a high degree on the social acceptance of technology that has been patented. One cannot market a patent if the political authorities – as a function of the societal assessments – do not approve it.

3. Ethical and Moral Issues

Green technology touches on our view of the world, changes the relationship of society with nature, and thus gnaws at cultural points of reference that for centuries have been informed by the idea of a preordained system of nature over which we have no power. This development is giving rise to moral resistance, especially as a result of the technical options which affect the nature of human life. Gene technology, is opening up ever more opportunities for making decisions on aspects of nature over which we previously had no decision-making powers, but which had to be accepted as destiny. This technology, thus fundamentally puts nature to a growing extent at our disposal and edges us increasingly into a technological relationship both with our own bodies and with non-human nature, thereby breaking down our traditional normative points of reference.

In the situation of an ever-growing number of people today there is a ever-greater demand for ethical guidance and a search of criteria to be applied in increasingly difficult decision-making processes. Gene technology is also the latest example of people finding themselves unable to cope with the dynamics of technological change. The feeling of being exposed to a development which is driving itself forwards without any sign of a rational control mechanism everywhere in sight creates anxieties and uncertainties, which in turn lead to new demands on politics and systems of democratic control. And it is precisely these background conflicts which are not being addressed:

- Is it technology alone that dictates how we live our lives?
- What is a human being?
- Will humans in future be created in the image of bioengineers?
- What makes human beings human, their genes or their social environment?
- What is our attitude to disease, disability and death?

These are questions that cannot be settled through the regulatory mechanisms of the law, but call for broad debate within society as a whole. A purely legalistic approach to intellectual property in gene technology concerning human beings could cost dearly on the social acceptance side.

In face of the diverse challenges posed by the modern biosciences (biology and medicine), there is one constantly recurring question: should we be allowed to do anything we are capable of doing? Ultimately, this is a purely rhetorical question, because there can always only be one answer: No! But where do we go from there? What is the moral consensus within society that enables us to get a broad societal acceptance of a complex and difficult-to understand technology in general – and gene technology in particular? What are the fundamental values and minimum conditions of human coexistence of such a technology?

Yes, it is above all the protection of people's dignity, rights and self-determination. Anything, however, which goes beyond this, often falls into a pluralism of moral convictions and has little chance of finding consensus within society.

Where are pathways which, on the one hand allow for a proper IP handling and, on the other hand, take into consideration differences of values and convictions as well as pluralism of interest? How can we best initiate an informed public debate in order to share the dilemmas that arise in dealing with these issues? How can we shed light on the complexity of the issues involved without losing a lay public's attention?

If we look at gene technology in healthcare, the complexity of the issues involved becomes obvious – simple answers beyond the smallest common denominator are impossible.

4. Gene Technology in Healthcare

In principle, gene technology provides us with opportunities to take power over the nature of life in the same way that physics and chemistry enabled us to take power over matter. Gene technology, genetic diagnostics or reproductive medicine are facing us with a host of questions whose importance is in inverse proportion to the degree to which they can be answered. Questions such "Where should we stand in our attitudes to death and disease in face of the technological options available to medicine?" are touching on the basic meaning of our existence as well as on the tenets of our thinking and our moral intuition. This is not a new situation:

From the early discovery of pathogens by Pasteur, the first vaccinations, the surgical operations on heart and brain through to modern reproductive medicine and gene therapy – all these events were always accompanied by debates on whether these advances were not crossing barriers into realms for which not even medical indications could provide any more justification.

Over the past 100 years and also today, the restoration of health appeared to have justified almost any technological intervention. This is linked to the fact that, within the value systems of liberal societies, medicine enjoys undisputed legitimacy. It is therefore not surprising that gene technology seems to enjoy the highest degree of social acceptance precisely where the moral barriers are at their highest, namely with its use in humans.

To gain societal acceptance necessitates a weighting process of the advantages against the disadvantages. And in consequence of this need, any moral position that tries to defend some indiscriminate proscription will find itself left out in the cold. Moreover, it is clear that the prevailing definition of disease in our culture serves very much as a suitable regulatory mechanism against the arbitrariness of technology. This concept of disease is itself informed by certain moral barriers and professional standards which limit both the power of technology over humans and the scope of action of the medical doctor. According to this concept, an application of gene technology in medicine is only justified when a disease is present and treatable.

One has to be aware at the same time, however, that the definition of disease is also rather blurred in place, for example in the area of mental disorders. But for the majority of cases where we experience disease in everyday practice and regard the hospital as competent to deal with disease, the definition works. And those standard cases in which medical use is made of test methods based on molecular genetics and techniques of gene therapy also fall into this category, because they focus on physical suffering and derive from this their undisputed legitimacy.

Precisely in the area of diagnosis by means of molecular genetics, research into the human genome in recent years has made particularly impressive advances and in many cases also led to new strategies of prevention. It is possible, for example:

- to predict diseases which will not occur until later on in the life of a person;
- to identify particular genetic susceptibilities of a person to environmental toxins;

- to detect genetic traits which do not lead to problems in carriers but may under certain circumstances cause severe disorders in their offspring;
- through early detection of genetic mutations in individual cases to take preventive action and thereby prevent the manifestation of a disease (genetic predisposition to cancer of the colon, breast cancer etc.);
- through genetic counselling to draw the attention of parents to the risks of reproduction and in this way to avoid producing disable children;
- to detect genetic damage to the fetus in prenatal diagnosis and, through abortion, to prevent the birth of disabled offspring.

All these possibilities certainly have an undeniable benefit, but are also not without risks and problematical moral dimensions of their own:

- Are we threatened with an unbridled genetic investigation of people?
- Could genetic traits also become a criterion for social discrimination – e.g. at the workplace or for health and life insurances?
- Will cost pressures on the healthcare system and a "perfect child" mentality among parents favour eugenic selection on a major scale?

One of the moral problems of widening our genetic knowledge concerns, for example, the practice of prenatal diagnosis, because most women involved are at most ambivalent about the possibility of a molecular genetic test before childbirth: on the one hand, these tests are performed to settle suspicions and fears with regard to possible diseases in children not yet born. At the same time, these tests are also feared because, in the event that they might produce a medically positive result, they entail making a decision on whether to continue with the pregnancy or to terminate it.

As our genetic knowledge grows, this conflict will intensify further, because it is a knowledge that enables more and more diseases and developmental disorders to be identified. The moral core of this problem lies in the fact that diagnoses which bring abortion in their train have nothing to do with selection. After all, in every case in which a termination of pregnancy is considered, it is a question not of providing therapeutic care for a person afflicted with a disease but of preventing that person's birth – a procedure which may well be understandable in terms of the individual decision of a mother faced with such a decision, but should never be acceptable in terms of a health policy programme.

New findings from the human genome research project are also opening up the possibility of genetic testing for diseases that have not yet become clinically apparent. A number of genetic diseases do not manifest themselves until an advanced age. People who know from their family history, for example, that they are at risk already have the possibility today, by means of a genetic test, of substantiating what may only be a presumed risk or of reducing or even eliminating the risk altogether. But it is not only people at risk for whom these tests are an issue. If one takes into account not only hereditary factors in the narrower sense, but also other genetic determinants of diseases, then predictive genetics instantly becomes an issue for almost everyone. Because in cardiovascular diseases, cancer, allergy, diabetes, endogenous depression, and schizophrenia – in all diseases – genetic factors play a part, a fact that should remind us that every one of us is carrying around a number of genes which are capable of causing disease.

Does it make sense to know such personal risks under any circumstances? The question one has to ask oneself here is whether, as an individual, one should not also have the right to forego knowledge about one s own genes. Although it can clearly make sense under certain conditions to plan one's life in the knowledge of one's genetic constitution, this is not something which appeals to everyone. One may prefer not to know in advance the risks one is living with, and perhaps also the serious and unavoidable diseases that one may be faced with. This does not have to be an arbitrary preference; on the contrary, a decision of this kind may result from the choice of a certain lifestyle and at the same time be an expression of views, possible of a religious nature, on the meaning of human life. If someone makes a decision of this kind, then it must be seen as an exercise of his or her personal rights and must be respected as such. The basic right to self-determination in this age of information includes not only the right to know about any genetic information that is available, but also the right to forego that knowledge.

Yet with all the fascination of the developments in this field, we should retain a certain modesty with regard to the potential that resides in the knowledge at our disposal. Despite the enormous growth in our understanding of the molecular and genetic disorders underlying many diseases, we are still a long way from fully comprehending the complex interplay between genes and the environment. And accordingly we are already seeing in many areas of genetics the outline of substantially more complex picture of how disease develops. Linear correlations between an isolated "defect" in a gene and the clinical picture of a disease tend to be the exception rather than the rule, even in so-called monogenic diseases. Most diseases tend to be the result of a complex interplay of several genes with so-called epigenetic factors and environmental influences. In face of these findings, the objection which is often raised against gene technology that – especially in the context of human genome research – it promotes a reductionist view of human life is refuted by the results of genome research itself.

For all the intensity of both the material and the non-material promotion of gene technology research in the field of healthcare, our efforts to deal with disease and suffering must not be allowed to focus exclusively on technical solution. It is also no less important that we do not imagine that all we need is to invest a lot of money etc. in research and then we can get disease, suffering and death "under control" so to speak. On the contrary: just as we need to optimise the technical options at our disposal, so too do we need to activate our human resources and to ask ourselves whether, in dealing with disease, there might not be other options available apart from technical solutions, however important the latter might be in individual cases. But this is a question that does belong in the realm of science. It is an issue that concerns us all. The humanity of a society, after all, is measured not by its ability to exercise technical control over disease and suffering, but by the degree to which society succeeds in integrating people with incurable and chronic disease and suffering into its healthcare system and respecting them in their dignity as human being regardless of their physical and/or mental handicap.

The problems described and the questions asked in this context touch on fundamental values within our societies, and one has to ask oneself whether it is incumbent upon the law to define the limits of these and other gene technology options in the field of healthcare. We all perceive that not everything that is legal is also legitimate and we know that modern pluralistic societies want more than just the assurance that all is fine from the law's side. What are the consequences resulting from this perception and knowledge?

The more we extend our knowledge and technical skills in the future, as research into the human genome continues, the greater our responsibility becomes for the way in which we deal with the knowledge and skills. This responsibility includes, amongst other things, an honest public debate about the true scope of gene technology. Although gene technology will open up a number of new and important options in basic research, medicine and agriculture, it will not bring eternal life or permanent health. The debate will have to take ethical concerns seriously, it will have to shed light on the opportunity costs and benefits of different alternatives – and all parties will have to share the dilemmas that are arising from either road taken.

Transgenic Agriculture Reconsidered: Some Reflections

Carine Pionetti[*]

The expansion of transgenic crops has to a large extent been associated with industrial agriculture in a few countries like the USA, Australia, Canada, China and Argentina. In recent years, however, a major thrust has been placed on the potential of genetic engineering to address the problems faced by farmers in the developing world. A wide range of research efforts aim at the release of varieties resistant to damaging pests (in crops such as cotton and tobacco), to diseases and viruses (in potato, maize, tomato), to drought and varieties featuring greater nutritional value such as the "Golden Rice", a transgenic rice enriched with beta-carotene. This new generation of genetically modified organisms (GMO's) has enabled proponents of genetic engineering to give their technology a new legitimacy, founded on its alleged role in combating malnutrition, decreasing the need for pesticides or increasing crop productivity in rainfed areas.

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To the majority of scientists and policy-makers involved in the development of transgenic crops, there is little doubt that these are ultimately going to benefit small and marginal farmers in developing countries. It is not clear, however, on what grounds this view is founded. Examples abound of technologies widening socio-economic disparities instead of reducing them or undermining the livelihood of the most vulnerable sections of society, in particular in the field of agriculture. Assessing the impact of a new technology must, therefore, go beyond merely weighing its immediate benefits to potential users. What needs to be reviewed is the larger trajectory that leads to the development of a given technology, and the value system in which it is embedded. It is also important to keep in mind that the pursuit of a particular course in the generation of technology excludes a range of alternative directions, actors, and viewpoints. It is this approach which we will follow to understand and evaluate Bt cotton, the first genetically modified organism which is likely to be grown on a large scale in India. Beyond Bt cotton and its potential to small farmers, it is the wider political project underpinning transgenic agriculture, with its own history, ideology and prospects, which we propose to examine.

Though genetic engineering was heralded as a means of achieving multiple aims, like increasing the nutritional value of crops, reclaiming degraded soils or overcoming the risk of drought in dry areas, in reality, the vast majority of transgenic crops bear one of the two traits : herbicide tolerance and insect resistance (Table 1).

Since herbicide tolerant varieties entail buying both the seeds and chemical inputs (herbicide) from the same company, many critics have pointed out that these transgenic varieties have more to do with agri-chemical companies capturing a new market than with farmers' needs and benefits. One of the best known examples is that of Roundup Ready varieties engineered by Monsanto to be tolerant to its own Roundup (Glyphosate) herbicide.

Table 1. Dominant transgenic crops and trait combinations in 2000.

Crop	Trait (in million hectares)	Acreage	Transgenic area as % of global area
Soybean	Herbicide tolerance	25.8	36
	Insect resistance (Bt)	6.8	
Maize	Herbicide tolerance	2.1	7
	Bt + herbicide tolerance	1.4	
	Insect resistance (Bt)	2.1	
Cotton	Bt + herbicide tolerance	1.7	16
	Insect resistance (Bt)	1.5	
Rape seed	Herbicide tolerance	2.8	11

Source: ISAAA (2000)

Genetic engineering has recently received the unequivocal support of the United Nations Development Programme.[1] Singled out as a spearhead of agricultural development worldwide, biotechnology is made out to be the ultimate tool in meeting production challenges and reducing poverty. The literature on genetic engineering reveals a plethora of assertions such as: "The spread and dissemination of new technologies and modern inputs to the disadvantaged and less developed regions of the country will not only provide a major thrust to production but also benefit the poor. Innovations in the field of biotechnology, genetic engineering, geographic information systems, remote sensing, etc. can prove to be useful in improving the living conditions of the poor."[2]

We propose to review such optimistic projections in the light of three considerations, largely drawing from primary data gathered during fieldwork conducted in the year 2001 in three districts of the Telangana region of Andhra Pradesh.[3]

First, the adoption of 'modern inputs' by farmers - one of the keystones of the current agricultural development paradigm - is not, in and of itself, beneficial to small farmers. On the contrary, their livelihood has in some instances been put in jeopardy by the adoption of new agricultural practices and inputs, as in the case of cotton in Warangal district.

Secondly, the attention placed on the potential of genetically modified crops such as Bt cotton has served to overshadow viable alternatives currently practised in farmers' fields. This is illustrated by cotton growers of Kerimeri Mandal (in Adilabad district of Andhra Pradesh) who have stopped using chemical pesticides on their crop and simultaneously refined a number of cultivation practices, using inputs derived from local resources. This has enabled them to evade major crop losses due to pest.

Thirdly, the technology-driven paradigm of agriculture - which has given rise to transgenic crops - tends to alienate farmers from their own knowledge and resource base. This is especially true of women farmers, whose practices and outlook are not only ill understood but also undermined by current agricultural development trends.

The rationale for the emergence of transgenic crops lies, by and large, in the limits - not to say the failures - of another system: chemical agriculture. Where the package of hybrid seeds and chemical inputs is reaching a deadlock, genetic engineering comes to the rescue through the insertion of genes of related or unrelated species into crop varieties. Transgenic Bt cotton is heralded as the miracle solution for cotton growers across the globe. Yet there is little critical analysis of the reasons why cotton farmers in India are constantly banking on the next technological fix, leading in many cases to an utter loss of control over their means of livelihood. It is illusory to make any claim regarding the potential benefits of transgenic cotton to farmers - and particularly to the majority of small and marginal farmers - without taking a close look at this reality.

The wave of crises faced by cotton growers in Warangal district of Andhra Pradesh is a clear manifestation of how costly inputs jeopardise the livelihood of small farmers. The 2001 *rabi* season marked a new climax in this recent dramatic history as levels of pest attack reached those of the year 1997-98, when farmers first resorted to suicide on a large scale in the district. In the month of October 2001 (a peak month in the cycle of pest incidence in cotton), farmers of Rayaparthi Mandal were reporting that despite spraying very large doses of pesticides (representing an expenditure ranging between Rs. 5000 and Rs. 8000 per hectare), the *Helicoverpa* pest simply could not be controlled. This is hardly surprising considering the 600-fold resistance which the bollworm has developed to pesticides over the last ten years, according to cotton scientists of the district.[4] Today, the area under cotton cultivation represents close to 40 per cent of the total cropped area of Warangal district (compared to less than 1 per cent twenty years ago). Cotton is grown by farmers of all socio-economic categories, and on all types of soils, including soils that are basically unsuitable for this crop. The senseless spread of this crop in several districts of Andhra Pradesh is linked to several factors: the availability of credit (private money-lenders or pesticide dealers make loans accessible to farmers for commercial crops like cotton - never for food crops - at colossal interest rates, up to 48 per cent), the lack of remunerative prices for rainfed food crops, the myth of "progressive" and profitable high-input farming (vehicled by many large farmers and extension workers) and, last but not least, the need for money (which is growing with the progressive withdrawal of the government from primary services like education and health).

Throughout Warangal district, thousands of farmers have contracted large debts over the last two to three years in order to buy costly chemical inputs or dig a well to irrigate their crop.[5] In Kothuru village, farmers estimate that at least 75 per cent of households are indebted, with accumulated amounts ranging from Rs. 15,000 to Rs. 50,000. These high levels of debt prevent farmers from moving to other crops, as they feel that only a good cotton crop could enable them to repay at least part of their debt. This logic works against crop diversification, which affords small farmers some degree of livelihood security, especially in dryland environments. Several indicators reveal that their livelihood is today in jeopardy :

i) it is not rare for land-owning farmers to sell their cattle or an acre or two of land in order to clear a loan ;

ii) in certain villages, like Kothuru and Perkavedu, virtually all women belonging to socio-economically marginalised classes (Scheduled

Castes, Scheduled Tribes and Backward Castes) have mortgaged some jewellery, including their *mangalsutra*, a very sacred sign of marriage to Indian women;

iii) over the last two years, at least five families have permanently left the village of Kothuru, abandoning their land to money-lenders whom they could not repay.

Such instances ought to be interpreted as the ultimate loss of control over productive resources. Though this process is a complex one, there is no doubt that farmers are misled by a misconceived faith in the efficiency of 'modern inputs', especially the dozens of different pesticides marketed by some 600 dealers throughout the district. Emphatically speaking of his disarray with the trilogy of cotton, pests and pesticides, one farmer from Kothuru says: "Only poison is left with us now, nothing else". Echoing this sense of disillusion, an old man declares: "At first, cotton looks very sweet. But as you feast on it, it becomes a poison." A fine appreciation of the downsides of farmers' addiction to commercial agriculture.

What the case of Warangal cotton farmers goes to show is that the adoption of costly technological inputs in an inappropriate ecological, cultural and economic environment can indeed lead to the collapse of small farmers' livelihood.

Such evidence in no way deters proponents of biotechnology from asserting that genetic engineering serves the interests of farmers. This discourse is, in fact, necessary to justify the vast amount of capital and intellectual resources invested in the development of transgenic varieties both by the public and the private sectors. Bt cotton is thus presented as *the* way out of the infernal cycle of pesticide spray for cotton growers. This argument however does not hold when one considers the following drawbacks to the adoption of Bt varieties by small farmers:

a. The *Helicoverpa* pest invariably develops resistance to the Bt toxin transferred to genetically modified plants. In other words, the 'relief' provided by Bt cotton can only be temporary. The so-called 'refuge' zones are already proving grossly inadequate in controlling pest resistance in regions where Bt crops are grown on a large scale.[6]

b. The price of genetically modified seeds can only be expected to rise given the economics of seed patenting and the level of concentration in this sector: all GMO's in agriculture are today under the control of three agro-chemical companies.[7]

c. Gene transfers from GM varieties to non-GM varieties could ultimately make the cultivation of strictly non-Bt crops impossible (as it has happened in Canada in the case of rapeseed). The ex-Environment Minister of France has recently pointed out that large scale field tests of GMO's amount to a forceful introduction of GMO's into European ecological systems due to genetic pollution (which ultimately prevents the segregation between GMO and non-GMO products).[8]

There is little doubt that transgenic crops bring about new forms of economic and political dependency for farmers. In North America, companies like Monsanto have bestowed upon themselves the right to police farmers by sending surveillance teams to farms which planted genetically modified varieties, so as to ensure that no protected seeds are being reused. Though this grim prospect appears difficult to implement in India, it gives an idea of the kind of logic at work.

The emphasis placed on genetic engineering has obscured the fact that there are alternatives to GMO's, which are in many cases thought out and practised by farmers themselves, without external support. This is illustrated by a farmer from Kerimeri Mandal, in Adilabad district (which has a long tradition of cotton cultivation) who took it into his own hands to get out of the cycle of indebtedness he had fallen into. In the year 1997, he was the first cotton farmer of the area to completely opt out of pesticide sprays. Instead, he began to emphasise a number of time-tested cultivation practices on his 14-hectare rainfed farm of black sandy soils. One of these consists in enhancing soil fertility by applying farm yard manure to the land, every third year, and by growing, every fourth year, either blackgram intercropped with redgram in *kharif*, followed by *rabi jowar* (winter sorghum) or a monocrop of soyabean. When a crop of cotton is raised (using hybrid seeds), the following cultivation practices are strictly implemented:

- Deep ploughing in the hot month of April, using a bullock-driven plough, so as to:
  - uproot weeds growing on the land,
  - eliminate hibernating insect pests and their egg masses,
  - enhance the soil's water retention capacity, making early sowing possible.

- Sowing at the optimal time, i.e. in the first week of June, which:
  - minimises the risk of a pest attack (as cotton bolls form before *Helicoverpa* larvae develop),
  - increases the chances of a healthy crop, and of a good yield (late sowing can lead to yield losses of 20 to 30 per cent of the crop).

- Manual weeding done at regular time intervals (approximately every 25 days) so as to:
  - help the growth of cotton plants by diminishing competition with other plants,
  - reduce pest attack by limiting the number of host plants that can serve as refuge if insecticides are sprayed on the crop (farmers point out that if weeding is not done in the initial 45 days of the crop development, dramatic decreases in yield - up to 40 per cent - are likely to ensue).

- Pruning of plants after 100-110 days of growth, in order to:
  - remove tender leaves on which the *Helicoverpa* moth lays its eggs,
  - stimulate horizontal vegetative growth, to increase the number of bolls on each plant, and therefore gives a higher yield potential.

The result of all these practices is that the *Helicoverpa* pest no longer causes major damage to the crop. Over the last four years, this farmer has harvested an average of 8 quintals of cotton per hectare, which is 2 to 3 quintals higher than the usual yields in the area. The total cost of cultivation on his farm amounts to Rs. 9400 per hectare on average (+/- Rs. 500 depending on the extent of weeding and pruning required in a given year and the associated labour costs). This rate of investment is considerably lower than the investment made by farmers who purchase pesticides. The experience of this large farmer, whose cotton crop generates a minimum net income of Rs. 7000 per hectare, has inspired many farmers in the area (including small farmers) to likewise move away from pesticides. The Agricultural Officer of Asifabad Mandal (adjacent to Kerimeri) estimates that close to 1200 hectares of cotton are being cultivated without pesticides at present in the area (chemical fertilisers do remain in use). Though the income derived by small farmers are not as high as those of large farmers (due to lack of access to inputs such as organic manure), the problem of indebtedness has been kept at bay.

A network of seven grass-root level non-governmental organisations and three Krishi Vigyan Kendra have been working with farmers from Andhra Pradesh on alternatives to chemical pesticides, especially for pest-prone crops like cotton, pigeonpea and groundnut. The Non-Pesticidal Management (NPM) advocated by these agencies include practices that farmers have used in their fields for decades (such as rotating crops, improving soil fertility, spraying chilli-garlic extract, neem oil, jaggery solution on the crop, attracting birds) as well as new methods (pheromone traps, NPV virus inoculation of caterpillars). The implementation of NPM on 265 hectares of cotton has proved highly successful in terms of reducing the cost of cultivation both for dryland and irrigated cotton, which suggests that NPM ought to be adopted on a much wider scale.[9]

The experience of Kerimeri farmers gives ample scope to reconsider Bt cotton as the only and most adequate answer to the overuse of pesticides. The use and improvement of locally available resources, over which farmers have a greater degree of control, is a key factor in the pursuit of sustainability in agriculture. There is a great and urgent need to thoroughly document and promote practices and initiatives located within the economic, cultural and political reach of farmers.

The agricultural research model in place has done little to evaluate and depart from the multiple dimensions of farming in dryland areas. The technological improvements extended to farmers rarely build upon farmers' own resources and knowledge base, and often disregard the complex set of constraints under which small farmers operate. For centuries, farmers were developing their own technologies in their fields, drawing from their experience and needs. The advent of modern science and technology has, however, shifted the generation of technology to from farmers' fields to experimental plots managed by scientists who have little or no farming experience. The development of non-farm based inputs like chemical fertilisers, pesticides, herbicides has attracted a range of industries into the arena of technology generation.

In the seed sector, private players have largely focused their efforts on the development of hybrids that need to be purchased every year. The activities of the industry are protected by legislative measures like the protection of plant breeders' rights, which reinforces the control of seed companies over the improved planting material developed. The reductionistic science of genetic engineering has enabled the industry to develop so-called 'precise' means of inserting desired traits into living organisms. The amalgamation of the agri-chemicals and seed industries into the 'life sciences' industry through mergers and takeovers has in fact paved the way for the development of technologies like herbicide tolerant crops. The aggressive promotion by these companies of their technologies, backed, in more or less covert ways, by governments and the lack of proper public debate and information makes it possible for scientists, scholars or leaders of farmers' movements alike to claim that farmers have a fundamental right to technology, regardless of its value content, ecological risks, and political costs.[10] This mindset is largely responsible for the failure to seriously consider and assess the viable alternatives existing in farmers' fields.

The development of technology by specialists whose fields of 'expertise' do not extend to socio-cultural and political domains has led to a profound disregard towards the gender dimension in agriculture. Though there is a lack of gender-disaggregated data pertaining to agriculture and to the adoption of new technology, there is no doubt that gender plays a determining role in how farmers manage, access, select or discard resources and technology.[11]

A series of participatory rural appraisals (PRA's) conducted with small dryland farmers in the districts of Medak and Adilabad between 1999 and 2001 brought to light the importance of gender in understanding and using crop diversity. In Sattmoori, a village of Adivasi Gound farmers located in Adilabad district, a PRA on crop diversity revealed that women pay more heed to its nutritional, ecological and cultural values than men do. These benefits range from nutritious foodgrains, to green vegetables, dry and green fodder for the cattle, fencing material, oil (from crops like sesame and safflower), ingredients for festival delicacies, food offerings, herbal remedies. The only benefit derived from cotton (which is gaining ground in the area despite the prevalence of red soils which severely limit its yielding potential) is a meagre sum of money. In a women-only group discussion, women farmers clearly stated that cotton laid low on their own agendas of crop choices, but higher on their husbands'. Indeed, men farmers have been the direct targets of 'agents' of commercial agriculture (like extension workers, breeders, inputs dealers, money-lenders, commission agents...). While there is no outright rejection of marketable crops on women's part (in fact, small dryland women farmers readily grow semi-commercial crops like coriander, castor, chillies, bishop's weed), a strong sense that these should not be grown at the cost of crops that meet more immediate food, fodder and fuel needs does pervade.

To many small women farmers of dryland regions, crop diversity - a time-tested way of dealing with the risk inherent to rainfed farming - is also a concealed way of retaining control over the crop. In the village of Chillamammadi, in Medak district, a small farmer explains that if she grows a single variety of chickpea or redgram, the harvest comes to around a quintal, which her husband may well be tempted to sell in the market. If, instead of one, she sows two or three different varieties (black, red and white redgram for instance), the harvest of 25 to 30 kg of each variety is more likely to be used for home consumption as these quantities are not really worth selling.

This account corroborates findings from different continents, which show that women play a leading role in decision-making where farming systems retain a high degree of local resource use.[12] In the modern, high external input, market-based model of agriculture, the source of knowledge and information shifts away from the community, and men often become the main decision-makers with regards to crops, but also inputs, operations, marketing opportunities.

The lack of understanding of gender-specific perceptions and priorities in agriculture can be seen as one major reason for the emphasis on commercial crops as the panacea of agricultural development. Crops like cotton, groundnut, sunflower or sugarcane have been construed by policy-makers as a sign of modernity and promoted via a number of schemes (credit, access to irrigation...) which undermine women farmers' capacity to pursue the kind of agriculture suited to their needs and priorities. The proposed agricultural policy for Andhra Pradesh, "Vision 2020", is full of references to the necessary expansion of commercial crops and of contract farming as a means of modernising the State's agriculture. Interestingly, the issue of women's control over land, water or seeds is entirely evaded. Women are only distinctly referred to in the "Vision 2020" document as potential beneficiaries of new employment opportunities generated by the expanding poultry and dairy sectors. A sad proposition when compared to the array of skills and knowledge women farmers' display in their daily practices of dryland agriculture in the Telangana region...

In June 2001, a Citizen's Jury on Food and Farming Futures in Andhra Pradesh took place in Medak district over a six-day period.[13] A Jury composed of small and marginal farmers (13 women and 6 men belonging, for most of them, to Dalit castes) debated and evaluated three scenarios for the future of food and farming systems in the State, one of which was "Vision 2020". This exercise in deliberative democracy was built around direct interactions between Jury members and twelve witnesses exposing varied viewpoints. When presented with genetically engineered rice aimed at improving the health of children in poor countries, Jury members from the Telangana region showed little enthusiasm, as they found their own traditional millet and pulses-based diet unbeatable in terms of nutrition. Others emphasised their confidence in their own knowledge and crops, and, simultaneously, their discontent with chemical agriculture, which has led them to having to buy more and more fertilisers and pesticides. They also condemn the amount of money spent on biotechnology, stating that this money could instead be diverted to help them achieve a vision of their own.

The concerns of small farmers with regards to genetic engineering is perhaps best summed up in the final Verdict delivered by the Jury, which addresses issues of seed and GM crops, but also self-reliance, mechanisation, land consolidation, unfair pricing. In their Verdict, farmers reject GM seeds, arguing that this technology, which is basically alien to them, may damage their lives and livelihoods. This stand greatly contrasts with the views upheld by many scientists and policy-makers that transgenic crops are bound to improve the lives of poor people.

Endnotes:

[1] *Human Development Report* (2001).

[2] Srinivasan, P.V, and Jha, Shikha, (2000).

[3] This fieldwork is part of a Ph.D. Research in Political Ecology on Women farmers' control over seeds in diversity-based and commercial agriculture on the Deccan Plateau, registered at the University of Orléans in France.

[4] Personal communication with Dr. Jalapathi Rao, Principal Scientist of the Agricultural Research Station of Warangal.

[5] Venkateshwarlu, D., Srinivas, K., Murali, R, (2000).

[6] Rissler, Jane, and Mellon, Margarat (1996).

[7] RAFI Communiqué, Jul/Aug. (1993).

[8] Lepage, Corinne (2001).
[9] Centre for World Solidarity (2000-01), Progress Report.
[10] Omvedt, Gail (2001).
[11] Poats, Susan (1991).
[12] Fahy-Bryceson Deborah (1995).
[13] This Citizens' Jury - Prajateerpu in Telugu - was facilitated by the UK-based International Institute for Environment and Development and the Institute of Development Studies, in collaboration with three national partners: the Andhra Pradesh Coalition in Defence of Diversity, the University of Hyderabad and the All-India National Biodiversity Strategy and Action Plan (NBSAP). The witnesses included representatives from the Government of Andhra Pradesh, the International Federation of Organic Agriculture Movements (IFOAM), the agro-chemical firm Syngenta, the Andhra Pradesh Federation of Farmers' Association, the NGO Anthra specialising on livestock issues, the International Forum on Globalisation (UK). For more details, see www.iied.org/agri/IIEDcitizenjuryAP1.html.

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Implications of Codex Standards for the Regulation of Genetically Modified Food[1]

Judson O. Berkey*

The full effect of Codex standards will ultimately depend on how the standards are treated within the WTO because the WTO provides the forum where any disputes over the trade effects of these standards will be settled. Thus, the development of Codex standards will still not provide complete clarity on the rules governing the trade of genetically modified foods. The Codex Alimentarius (Codex) is a commission jointly sponsored by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO). Codex adopts standards that may be used by its 162 participating governments to develop national regulations. Codex is currently developing a variety of international standards for the trade of genetically modified food (GMF).

Codex has three committees that are considering various issues related to GMFs. These committees are the following: 1) Codex Committee on Food Labeling (CCFL); 2) Codex Committee on General Principles (CCGP);

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1 This document is brought out by The American Society for International Law (ASIL).

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and 3) Ad Hoc Intergovernmental Task Force on Foods Derived from Biotechnology (Task Force).

1. Codex Committee on Food Labelling (CCFL)

The CCFL currently is considering two different labelling options for GMFs. Under Option 1 (proposed by the U.S.), all foods derived from biotechnology or containing ingredients derived from biotechnology would be labelled as such only if the altered food differs from the original food in terms of composition, nutritional value, or intended use.

Labelling would also be required if the genetic modification introduced a known allergen into the food. In order to implement this option, it will be necessary to determine the degree of "difference" that triggers the labelling requirement. The U.S. is on record as supporting a "differs significantly from" standard as opposed to a "is no longer equivalent to" standard.

Under Option 2 (proposed by the EU), all food composed of or containing ingredients with genetically modified material would have to labeled as such. In addition, labels would have to state the method of production for the GMF (e.g., "produced by genetic modification"). This option may or may not contain a threshold level to determine the minimum genetically modified content that triggers the labeling requirement. The EU has recently approved its own internal GMF labeling requirement with a 1 per cent threshold level.

At its most recent annual meeting on May 9-12, 2000, the CCFL agreed to spend another year considering these initial two options and a third option proposed by Norway and India. This third option would require labelling of foods in which genetically modified material has been used at any time during the production process. The practical effect of this proposal would be to require labelling of refined oils (e.g., vegetable oil) that are made from genetically modified crops (e.g., soybeans) even though they no longer contain any genetically modified material in their final form. The next meeting of the CCFL will occur in April 2001.

2. Codex Committee on General Principles (CCGP)

The CCGP is currently considering the application of the "precautionary principle" in the process of risk analysis. The CCGP is current draft document, Proposed Draft Codex Working Principles for Risk Analysis, contains a set of principles for risk analysis that are "intended for application in the framework of Codex Alimentarius and are also intended to provide advice to governments where applicable." Thus, the working principles will be slightly different from the typical Codex Standard in that they will serve not only as a standard but also will govern the development of new Codex Standards as well.

The draft document currently contains two alternative precautionary principles. The two alternatives (emphasis added for comparison) are as follows:

1. Where relevant scientific evidence is insufficient, precaution can be exercised as an interim measure to protect the health of consumers. However, additional information for a more objective risk assessment should be sought and the measures taken reviewed accordingly within a reasonable time.

2. When relevant scientific evidence is insufficient to objectively and fully assess risk from a hazard in food, and where there is reasonable evidence to suggest that adverse effects on human health may occur, but it is difficult to evaluate their nature and extent, it may be appropriate for risk managers to apply precaution through interim measures to protect the health of consumers without awaiting additional scientific data and a full risk assessment, in accordance with the following criteria: The most obvious difference between these two alternatives is that, the first requires a review of any measures taken according to the precautionary principle while the second only states that any measures should be considered "interim" measures. A second notable difference is that while the second alternative provides some indication of what constitutes "insufficient" scientific evidence (i.e., that which is lacking, but would be necessary to "objectively

and fully assess risk"), the first does not. The CCGP has formed a working group that will attempt to better define the precautionary principle by its next meeting in April 2001.

Task Force on Foods Derived from Biotechnology

At its most recent biennial meeting on June 28-July 3, 1999, the Codex Commission established the Ad Hoc Codex Intergovernmental Task Force on Foods Derived from Biotechnology to "develop standards, guidelines, or recommendations, as appropriate, for foods derived from biotechnology or traits introduced into foods by biotechnology, on the basis of scientific evidence, risk analysis, and having regard, where appropriate, to other legitimate factors relevant to the health of consumers and the promotion of fair trade practices." The intent was for the Task Force to develop GMF safety and nutrition standards while the CCFL addressed labelling issues and the CCGP considered the precautionary principle.

The Task Force met for the first time in on March 14-17, 2000. At the meeting, the Task Force agreed to develop a set of overarching principles for the application of risk analysis that would include the following elements: science-based decision making; premarket assessment; transparency; post market monitoring; and other legitimate factors as appropriate. The Task Force also agreed to develop a set of guidelines for risk assessment that would include the following elements: food safety and nutrition; substantial equivalence; potential long term health effects; and non-intentional effects.

The Task Force is currently preparing discussion papers on the concepts of food ingredient traceability and familiarity for consideration at its second meeting in March 2001.

Relationship of Codex to the WTO

Two WTO agreements are relevant for Codex standards: 1) Agreement on Sanitary and Phytosanitary Measures (SPS Agreement) and 2) Agreement on Technical Barriers on Trade (TBT Agreement). The SPS Agreement applies to those national laws designed to protect life and health from risks that arise from, among other things, additives, contaminants, toxins, diseases and pests. The TBT Agreement applies to all national technical regulations and standards governing product characteristics, labelling and packaging. These agreements provide the conditions under which national laws and regulations that may otherwise be considered to be trade restrictive, can be justified.

Although it is not yet clear whether the SPS Agreement or the TBT Agreement will apply to GMF regulations, the particular agreement that does apply will make a material difference in how any disputes are treated under the WTO. The SPS Agreement requires national measures to "conform to" international standards including those developed by Codex. National measures may be more stringent than international standards (e.g., requiring GMF labels on foods with a lower threshold trigger level than that which may be set by Codex) only when there is "a scientific justification" for doing so, or, in the absence of adequate scientific evidence, when the member country adopts a measure based on "available pertinent information, including that from the relevant international organizations" and continues to seek information necessary for "a more objective assessment of risk...within a reasonable time."

Under the TBT Agreement, on the other hand, national measures only need to be "in accordance" with international standards, which may or may not include Codex standards. This requirement in and of itself is weaker than that of "conformity" as required by the SPS Agreement. In addition, under the TBT Agreement, a national measure may be more stringent than an international standard when the standard would be an "ineffective or inappropriate means for the fulfillment of the legitimate objectives pursued, for instance because of fundamental climatic or geographic factors or fundamental technological problems." This is definitely a weaker standard than the requirement of "scientific justification" under the SPS Agreement. The full effect of Codex standards will ultimately depend on how the

Biotechnology News from Across the World

Argentina finds and destroys illegal GM seeds

Argentine agriculture officials destroyed a batch of unapproved genetically-modified seeds and began an investigation to determine who was responsible for distributing them. Having detected unauthorized genetically-modified crops and seeds, the Agriculture Department dedicated itself to locating and destroying the materials. Argentina is one of the world's biggest users of genetically-modified products, which must be approved for use by the government. Argentina has been studying the use of genetically modified Roundup Ready (RR) corn, but has yet to approve it.. The seed is genetically engineered to be resistant to the "Roundup" brand herbicide glyphosate so that farmers can eliminate weeds in fields without harming their crop. After passing field and toxicity tests, the government held up approval of RR corn on concern it would hurt exports to Europe, especially to Spain and Portugal, where the country sent 1.75 million tonnes of the grain in 1999/2000. According to the government, this strategy helped Argentina wrest market share from the United States, where RR corn is approved. RR soybean seeds made by U.S.-based biotechnology company Monsanto (MON) have been approved for use in Argentina since the 1996/1997 campaign and account for nearly 90 per cent of the 10.43 million hectares sown with soy.

(***Source:*** www.checkbiotech.org, May 03, 2001)

Argentina approves GMO seed

Argentina approved a genetically-modified cotton seed, reopening the door to biotechnology products after refusing to authorize their use in the country for nearly three years. The country stopped approving the use of genetically modified agricultural products in July 1998, influenced by rejection of the products by European consumers. Europe is the principal consumer of Argentine corn. The de facto suspension was extended to all crops, including cotton. The Agriculture Department resolution, will allow U.S.-based biotechnology company Monsanto (NYSE:MON) to sell a herbicide-resistant cotton seed called "Roundup Ready" (RR) in Argentina. Argentina, Latin America's third-largest economy, is second only to the United States in the use of genetically-modified seeds. The approval of the genetically-modified cotton brings the total number of genetically-modified products authorized for use in Argentina to six.

Three other Monsanto seeds are approved here, including insect-tolerant corn, cotton and soybeans. Aventis sells a herbicide-resistant corn seed locally and Swiss company Novartis sells an insect-resistant corn. ASA estimated farmers used genetically-modified seeds for 90 per cent of the record 10.4 million hectares planted to soybean in the 2000/01 campaign, more than 20 per cent of the area planted with corn and about 8 per cent of that sown with cotton. According to company estimates, within five years, this seed could be used for 60 per cent of the area planted in cotton. This means the economic impact of the cotton-growing provinces could rise by $50 million a year.

Unlike soybean production, which is expanding, the area planted to cotton in Argentina has been falling despite a small recovery this year. The government estimates some 410,000 hectares of cotton were planted this year, more than the 345,000 hectares a year ago, but far from the 1.13 million sowed in 1997/98. Cotton is produced mainly in the northern province of Chaco, about 620 miles (1,000 kms) from Buenos Aires. Argentina has a three-stage commercial authorization process for GMO products: field tests; a toxicology analysis to prove the product is not harmful; and finally an evaluation of the possible reaction of export markets.

(***Source:*** www.checkbiotech.org, May 03, 2001)

Brazil's shamans demand biopiracy laws

Medicine men and shamans from the Brazilian Amazon are calling for greater legal protection from companies that seek to patent their traditional knowledge and plant genetic resources, as well as government-funded training for indigenous people on their intellectual property rights. The shamans also called for the creation of a database of traditional knowledge that could be used by researchers for a fee.

In a letter sent to a meeting of the World Intellectual Property Organisation's (WIPO's) Intergovernmental Committee on Intellectual Property that takes place in Geneva, Switzerland, the participants rejected all forms of patenting based on traditional knowledge. Their land is home to a large part of the world's biological diversity — almost 50 per cent — which has great social, cultural, spiritual and economic value. Yet 97 per cent of the 4,000 patents taken out on natural products in Brazil between 1995 and 2000 were requested by foreigners, according to the Brazilian government. Venezuela has already created database of around 9,000 traditional practices. Brazil is larger and has more indigenous communities and could have 30,000 traditional practices in its database.

If a researcher wants to use information in the database, they would have to pay for it. The money would be invested in projects for the indigenous community. The indigenous representatives call for the creation of a fund, managed by indigenous people, to finance research by community members. The letter has been presented by INPI to State members of the World Intellectual Property Organisation (WIPO) at the second session of its intergovernmental committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore.

(***Source:*** www.checkbiotech.org, December 17, 2001)

Price controls stifling innovation

Europe is rapidly losing ground to the US in the pharmaceuticals industry because of heavy controls on medicine prices. Low prices for new drugs in most European Countries were stifling innovation and forcing the industry to move more activities to the US. Europe is clearly losing out in what will be one of the growth industries of the twenty-first century. Investment and jobs are being lost to the US because of pricing rules.

International drug companies have long complained about the low prices they receive from government-run health systems in Europe and have suggested that Europeans benefit without being financed by the larger profits in the US, where there is a freer market for drugs. All European governments have continued to press companies to reduce drug costs. The European Union this year took steps to streamline the process for approving new medicines in an attempt to attract more research projects to its member countries. Europe risks the loss of its drug industry to the slow grinding erosion of resources. In the 1980s Europe was considered the world's medicine chest, but it has now been displaced by the US as the industry's centre of gravity." France and Germany had essentially destroyed their local industries through their price rules. While there were still large drugs groups in Europe, the successful ones had shifted many activities to the US. Many European companies were declining, with Germany's Bayer – which has issued three profit warnings this year and withdrawn one of its top-selling drugs on safety grounds – being the classic example. The same was true of Japan, he said, where there were cases of multinationals refusing to launch products because prices were too low. The benefits of the US model in encouraging innovation were most evident in the biotechnology sector. The largest biotechnology company in the US was bigger than the whole European bio-tech sector combined.

(***Source:*** *The Financial Times,* November 6, 2001)

NSF boosts funding for plant genome research

The National Science Foundation (NSF) of USA has awarded 24 new grants totaling more than $71 million over the next five years for plant genome research. These awards will be shared by 109 investigators at 39 institutions in 27 states.

The latest grants bring NSF's total investment in the National Plant Genome Research Programme to more than $215 million. Many of these new projects build upon research success from the previous three years of the programme. For example, when NSF began this programme in 1998, only about 3,100 segments of DNA, known as expressed sequence tags (ESTs), were identified in corn and available in the public databases. Now, 106,595 ESTs are identified in corn and another 285,925 in soybeans. At the NSF, the overall plant genome research programme was designed to build an understanding of the structure and function of plant genes important to agriculture, environmental management, energy and health. Individual research projects seek to understand, at the whole genome scale, how plants grow and what controls important plant traits. The research awards support studies of economically important crops like barley, cotton, corn, rice, sorghum, soybean and tomato.

Some of the new projects will focus on innovative methods for gene discovery and characterization. These include the development of homologous gene replacement, massively parallel signature sequencing and mutations induced by transposons. Scientists will investigate the genetic control of form and function in flowers, from flowering to seed production. Projects will characterize the genes controlling the differentiation of flower cells and examine genes that play a central role in development of plant features. Other research will investigate the complex gene networks that regulate plant response to environmental conditions such as: drought, disease, temperature and flowering time. The growing field of bioinformatics will be critical to processing the volumes of data from the Plant Genome Research Programme. Two new NSF awards are focused on developing tools to accurately manipulate the data and make it accessible to the wider community. Researchers will develop new computer algorithms to process data and new interfaces for scientific manipulation of the data.

(***Source:*** www.checkbiotech.org, Nov 2, 2001)

NSF awards University of Georgia $8.7 million for crop genetics research

The National Science Foundation has awarded three grants to the University of Georgia to support research which aims to decipher the genetic blueprint of economically important crops in the grass family and identify useful genes for crop improvement, such as ones that confer drought tolerance. The total value of the awards is $8.7 million over four years. The grass family, which includes valuable food plants, is unrivalled in terms of economic and ecological importance. The research that these NSF awards support will not only advance knowledge in basic plant genetics but also may lead to improvements in crops such as sorghum, rice and wheat.

(***Source:*** www.checkbiotech.org, Nov 2, 2001)

Putting genes in context

A four-year, $3.97 million award has been given to UGA plant geneticist Andrew Paterson and collaborators at UGA, Clemson and Cornell to "apply genetic maps and genomic tools to better understand sorghum biology and productivity. Sorghum is the world's fifth most important cereal crop and second most important feed grain, with an annual value of $1.5 billion in the United States alone. One phase of this project is to build the skeleton on which the research community will be able to flesh out a complete sequence of the sorghum genome, much like the publicly-funded human genome project in the '90's.

Other phases of this project will look beyond the information available from sequencing. How a gene functions and how it is inherited are influenced by the genes and other non-genic DNA that are near it on the chromosome. This relationship is reflected in the order of genes along the chromosomes, the density of genes and "junk DNA," and the levels of diversity in genes that are found in natural populations of plants.

There's a lot known now about the human genome, for example, as the result of sequencing but there will be much more learned as the sequence is placed within its native context — the context of a chromosome. One project goal will be to develop a sorghum physical map that shows the actual location of genes and other markers on the chromosomes and includes a wide variety other data.

By comparing the genetic make-up of the two crops, Paterson hopes to learn which genes are involved in making seeds and which are involved in producing biomass — the leaves, stems and roots. As an alternative to fossil fuels, there is renewed interest in developing biomass crops as a possible sustainable energy source.

Paterson's grant is a renewal of a $3.2 million NSF award made three years ago. The earlier grant concentrated on building a basic toolkit to enable researchers to ask genome-wide questions in sorghum.

(***Source:*** www.checkbiotech.org, Nov 2, 2001)

Looking for genes to help crops adapt

UGA plant scientist Lee Pratt, a co-investigator on Paterson's earlier grant, received $3.6 million to pursue a different line of sorghum research over the next three years. Pratt's group aims to identify genes that improve plant growth in adverse environments. Their goal is to focus on genes related to various kinds of stresses, especially abiotic ones such as high light exposure, air pollution, drought and soil nutrient limitations.

In the earlier grant, Pratt's lab identified 15,000 unique sorghum genes. By the end of the new project, he said he expects to have increased the total number of genes isolated to 20,000, which may represent as much as two-thirds of all sorghum genes. Pratt's group also will determine which of these genes are active under stress conditions by using a new method called microarray technology where expression of thousands of genes can be detected simultaneously.

To handle the large volume of biological data that will be generated by the project, powerful computer-based tools will be developed to manage and analyze data and share it with other researchers. The use of bioinformatics — an emerging discipline at the interface of biology and computer science — will facilitate the discovery process by allowing researchers to mine the data quickly to detect genes and link diverse kinds of information.

In addition to research, the grant provides for undergraduate training in these new technologies. Currently, Pratt's lab recruits undergraduates from under-represented groups with majors that range from pre-medicine to pre-law to business. Ten or more students will work in his lab at a time, learning everything from DNA sequencing to bioinformatics. Collaborators on the project include researchers from Texas A&M, the U.S. Department of Agriculture's Agricultural Research Service and Tokyo University.

(***Source:*** www.checkbiotech.org, Nov 2, 2001)

Genes to revolutionize plant improvement

A third award of $1.1 million will support Tifton-based horticulture professor Peggy Ozias-Akins' work on grass family genetics. Ozias-Akins' lab will focus on a wild pearl millet relative that has a trait called apomixis — a botanical curiosity where plants produce seeds that are clones of the mother plant.

Apomixis is not a common trait but it is more frequently observed in the grass and sunflower families. This trait is rare in domesticated plants and absent from our major crops. If the trait for apomixis could be introduced into crops by gene transfer, it could revolutionize plant improvement and seed production.

There is huge significance in use of apomixis in agriculture, for example, a lot of self-pollinating crops such as peanuts must be 'selfed' for several generations before a new variety can be released on the market. Apomixis would make it quicker for plant breeders to get new varieties on the market and seed production in high performance hybrid varieties would be greatly simplified. Other UGA collaborators for these three grants include: John Bowers, Joann Conner, Marie-Michèle Cordonnier-Pratt, Alan Gingle and Daniel Peterson.

(***Source:*** www.checkbiotech.org, Nov 2, 2001)

UN food agency approves GM framework

The United Nations food agency has approved a framework for protecting the variety of the world's crops, seen as key to winning the war on hunger. The so-called International Convention on Plant Genetic Resources was originally agreed by member states of the UN Food and Agriculture Organisation (FAO) at a meeting at its Rome headquarters in July.

The convention, which aims to ensure that plant genetic resources can be preserved and made available for research and plant breeding, will come into force after it is ratified by at least 40 states. This new legally binding international agreement ... provides a framework to ensure access to plant genetic resources, and to related knowledge, technologies, and internationally agreed funding.

After years of anguished debate pitting poor countries and environmentalists against multinational corporations and wealthier nations, the United States agreed for the first time in July to mandatory payments by plant breeders developing new crop varieties in return for access to public seed banks. The seed banks lend out crop seeds, enabling research into new varieties of plants to increase resistance to disease and counter the impact of global warming. In turn, this helps alleviate hunger in poorer nations. The approval of the framework ended years of torturous negotiations and created an internationally accepted mechanism to protect agricultural biodiversity. The approval by the FAO conference of this International Convention on Plant Genetic Resources for Food and Agriculture is a milestone in international cooperation. Agricultural biodiversity must be saved in order to guarantee global food security as the population grows and the planet warms up. Plant varieties are becoming extinct at an unprecedented rate, according to the Italy-based International Plant Genetic Resources Institute (IPGRI).

IPGRI, an international body dedicated to the conservation and use of plant genetic resources for food and agriculture, estimates that every year more than 15 million hectares of tropical forest are destroyed. It says 8 per cent of plant species run the risk of extinction in the next 25 years. Over the past 50 years high-yielding uniform varieties of crops have taken the place of thousands of local varieties across large productive areas. Scientists will have to develop plant varieties resistant to drought, salinity and disease in order to increase the rate of food production to keep up with the expanding population, plant geneticists say. The FAO conference, which is also discussing the war on hunger, development programmes and livestock disease.

(***Source:*** www.checkbiotech.org, Nov 05, 2001)

UNIDO launches broad biotechnology initiative in Latin America

Agricultural and agro-industrial enterprises in Latin American and Caribbean countries stand to reap substantial benefits from a regional biotechnology initiative launched recently by the United Nations Industrial

Development Organization (UNIDO). At a meeting, the Vienna-based Organization outlined the mission of a Consultative Group called upon to assist the region in its efforts to seize the opportunities offered by rapid advances in biotechnology and deal with the challenges of biotechnology security and commerce.

The Biotechnology Consultative Group for Latin America and the Caribbean will include government officials and business leaders as well as prominent bio-scientists and experts from other fields. It will serve primarily as an independent discussion platform and advisory mechanism on issues related to the development and application of technologies relevant to agriculture and food processing. With agriculture and agro-industry accounting for at least 25 per cent of the regional GDP, and more than 40 per cent of exports, in most countries in the region, the potential benefits of biotechnology applications can hardly be ignored.

The Consultative Group will provide state-of-the-science advice to policy makers in full compliance with the need to preserve the regulatory sovereignty of the countries involved. Its services will also cover public perception issues as well as the emerging international regime of norms and practices in the trade with biotechnology and biotechnology products.

Assistance in charting out the best ways in which individual countries can tap their unique natural resources of biotechnological relevance is another key service that the Group will provide. This assistance will reflect a balanced approach giving due consideration to social, environmental and ethical issues. UNIDO will provide to the Consultative Group the technical secretariat and other types of support, including the services of its Regional Office in Montevideo. The Organization will also finance the initial stage of the project, while the Consultative Group itself will subsequently seek to secure further funding from various sources in the public and private sectors.

(***Source:*** www.checkbiotech.org, January 17, 2002)

UN reaches key agreement to save crop diversity

The UN world food body reached a landmark agreement to try to save the world's diversity of agricultural crops. The pact followed an anguished debate pitting many poor countries and environmentalists against multinational corporations and wealthier nations. After a week of touch-and-go talks, delegates said the United States had agreed for the first time in a public forum to mandatory payments by plant breeders and geneticists developing new crop varieties in return for access to public seed banks. The seed banks lend out crop seeds at no charge, enabling research into new varieties of plants to increase resistance to disease and ameliorate some of the impact of global warming.

In turn, this helps alleviate hunger in poorer nations. This international undertaking is a milestone, it will allow the conservation of genetic resources for future generations. An international agreement to conserve plant genetic resources was needed because agricultural biodiversity was being lost at an alarming rate. Esquinas-Alcazar estimated that over time some 10,000 plant species had been used for human food and agriculture, but now no more than 120 cultivated species provide 90 per cent of human food supplied by plants. Representatives of 161 countries reached the agreement by consensus in the early hours of Sunday at FAO's headquarters in Rome after tough haggling over the details. But a separate, core issue over the patenting of seeds, where rich and poor nations differ most, failed to be resolved. The biggest stumbling block was always the patents issue and after much agonised discussion, the meeting decided not to adopt a clause on intellectual property rights that limit access to seeds. The issue will be tackled instead by an FAO conference in November. Environmental groups say the patenting of food and seeds by multinational companies threatens food security and access by farmers to genetic resources.

The life sciences industry, on the other hand, believes that seed patents are a vital incentive for research. The agreement, encompassing 34 nutritional crop groups and 39 forage crop groups, underlined the need to protect farmers' rights, enabling them to save, use, exchange and sell farm-saved seed. Until now, seed exchanges have operated informally on the principle of "common heritage", an agreement that they are a shared international resource. Change has been forced by the UN Convention for biological diversity, which made nations responsible for their own genetic resources. FAO's November conference is expected to adopt the agreement, which will then be submitted to national governments for ratification.

(***Source:*** *Economic Times*, July 18, 2001)

Global plant gene treaty agreed

A new international agreement to use plant genes to help guarantee future world food supplies was hailed. The treaty was agreed at the weekend by delegates to a FAO commission in Rome after seven years of contentious negotiations.

It concerns the ability of western biotechnology companies to use raw materials from the developing world to breed new crop varieties. The treaty is regarded as a compromise that leaves many controversial issues, such as intellectual property rights, to be settled in the future. But concluding any agreement was seen as a success given the difficulties the talks have encountered in recent months. Clashes between developed and developing countries over intellectual property rights and a scheme for sharing the financial benefits of new plant varieties nearly sank the talks. It is a major international instrument reflecting the significance of access and benefit sharing as the basis for continued and sustainable utilisation of plant genetic resources for food and agriculture.

Despite approval of the treaty, an enormous task lay ahead to implement its provisions, in particular the need to ensure the genetic resources and local technologies developed by generations of farmers were enhanced by new genetic technologies and not replaced by them. The treaty was approved by 116 countries with the US and Japan abstaining. The US has insisted that WTO rules on intellectual property rights be applied without modification to the new treaty.

(***Source:*** *Financial Times*, November 6, 2001)

US criticises Sri Lankan ban on GM foods

The United States on Thursday criticised Sri Lanka's decision to ban all genetically modified (GM) foods and said the move would trigger an inquiry by the World Trade Organisation (WTO). Sri Lanka became one of the first countries to impose a total ban on GM foods, from May, 1 to avert suspected health risks. "We know of no credible scientific evidence justifying Sri Lanka's ban. We believe it is totally unwarranted," Weyland Beeghly, agricultural counsellor of the U.S. Embassy in neighbouring India, told a news conference in Colombo. Beeghly said the WTO had already called on Sri Lanka to provide scientific evidence to support its decision and added he saw little evidence other countries in the region would follow suit. "India is already pursuing its own bio-technology programme and there is very little chance that this will become a precedent for the region," he said. He said Washington had no plans to take bilateral action over the ban, adding it affected about only four percent of U.S. agricultural exports to Sri Lanka.

The United States accounts for about half the 900,000 tonnes of wheat Sri Lanka imports each year, but U.S. wheat is not genetically modified. GM foods contain a gene from another organism, generally to make them resistant to herbicides or to produce their own toxins to kill pests. Proponents of the new technology say it contributes to higher crop yields and lower production costs, while critics fear long-term health and environmental consequences. Sri Lanka, which said last year that it would impose the ban, has yet to announce a mechanism or system to test food imports for genetic modifications. Sri Lankan officials said they wanted the ban in place to give them more time to find out if GM foods were dangerous.

South Africa joins anti-GM lobby

In the run up to its hosting next year's Earth Summit, South Africa appears to have put itself in a bad light with environmentalists by pushing for curbs on the labelling of genetically modified (GM) foods. South Africa, along with Australia, this week emerged as two of the most pro-GM nations, calling for curbs on GM-free and non-GM labels at the World Trade Organisation's CODEX meeting underway in Canada.

Whereas the civil society has been calling for labelling, government has not made it clear whether it supports mandatory or voluntary labelling. This lacklustre attitude towards the issue has us wondering how South Africa could be hosting the Earth Summit when there is so little commitment to the environment. The legislation around GM food was so weak, the responsibility to actually enforce it has not even been properly assigned yet. Genetically modified crops have been planted in Gauteng - tomatoes at Roodeplaat Dam and maize in Carltonville - without the regulatory environmental impact assessments being done.

South Africa is also one of the few African countries that is also not signatory to the Cartegena Protocol. Close to 90 countries are signatory to the protocol, indicating that they do not want GM foods until issues such as labelling and greater environmental safety protocols have been properly addressed.

(***Source:*** Genet, May 7, 2001)

Crop design and SUCEST in functional genomics alliance

CropDesign N.V. (CropDesign) and SUCEST (Sugar Cane EST Genome Project) announced today that they have signed an agreement for a functional genomics alliance. The alliance targets the use of SUCEST's unique and functionally rich database of sugarcane genes with CropDesign's proprietary tools for developing crop improvement traits.

Under the terms of the agreement, CropDesign has been granted exclusive access to SUCEST's database for an undisclosed term. SUCEST and CropDesign will use their combined bioinformatics expertise to select candidate genes from the SUCEST database for crop improvement, including yield enhancement and stress tolerance. Selected genes will be entered into CropDesign's rice TraitMill™. The TraitMill™ is a comprehensive system for high-throughput evaluation of genes for crop improvement. The system comprises modules for bioinformatics, gene cloning, plant transformation and plant evaluation; all of which are automated for efficient, rapid and high-volume processing.

CropDesign is responsible for commercialisation of the results of the alliance outside of Brazil. Commercial exploitation in Brazil is the joint responsibility of the alliance partners. SUCEST will exclusively commercialise the programme results in sugarcane in Brazil.

SUCEST has built one of the most comprehensive plant genome databases integrating sequence and functional information with state-of-the-art data mining tools. Sugarcane is a close genetic relative of major cereal crops such as corn, rice and wheat, even though it is morphologically and physiologically quite distinct. Our access to these sugarcane resources combined with other cereal databases, will increase the efficiency of lead discovery in the TraitMill™. This agreement reflects our commitment to building a leading applied genomics product development company.

This deal highlights the position of SUCEST as a leading Brazilian research consortium with particular expertise in sugarcane molecular biology. Testing of genes from our database with the high-throughput power of the TraitMill™ is crucial to further understand their function. This agreement also leverages the value of SUCEST's extensive sugarcane genomics database in the marketplace. Brazil is responsible for 25 per cent of the world's production of sugarcane, and rice, corn and wheat are also amongst the country's most important field crops. This alliance puts us in a position to participate in the development of commercially attractive traits.

CropDesign, based in Gent, Belgium is an agbiotech company focused on the application of functional genomics for improved crop performance, including higher yield, heightened tolerance to stress and diseases and better quality. CropDesign applies its technology in rice, wheat and other cereals. Founded in 1998, CropDesign employs over 60 people at its research facilities in Gent.

SUCEST, based in Sao Paulo, Brazil, is the Sugarcane Genome Project funded by FAPESP, the Sao Paulo State research agency. SUCEST began sequencing the sugarcane genome in 1998 and has built one of the most comprehensive databases integrating genome sequence and functional information for that crop.

(***Source:*** www.checkbiotech.org, September 5, 2001)

Food patent and aid agency

Patents on staple food crops are giving agrochemical companies unprecedented control over the food chain, a trend that is jeopardising the ability of the poor to feed their families, claims a report published today by aid agency ActionAid. Companies are acting like "bio-pirates", taking plants from fields and forests in developing countries and applying for patents on them, it says. Patents give the owner exclusive rights to an invention for 18 to 20 years. While an invention should be novel to gain a patent, "patents are now being won on plant varieties where there is little evidence of novelty or invention", claims the report. The World Trade Organisation's agreement on Trade Related Aspects of Intellectual Property Rights (TRIPs), which came into force in 1995, effectively globalises the patent system.

Until then, patents were a matter of national policy and were only recognised in the countries where the application was made. A total of 918 patents have been taken out on rice, maize, wheat, soyabean and sorghum. Six companies – Aventis, Dow, DuPont, Mitsui, Monsanto and Syngenta –

hold 633 of these patents, or nearly 70 per cent. Farmers who grow patented crops might have to sign contracts and pay royalties to the patent holder and be denied the right to save, grow, exchange or re-sell seed. People in developing countries are concerned that farmers will be at the mercy of corporations and lose control over their food supplies.

Companies "are scouring the earth" looking for plant-based "green gold" to patent and then exploit commercially. Subjects of the "bio-piracy" controversy include basmati rice, broccoli sprouts, India's medicinal neem tree, the fragrant ilang ilang plant native to the Philippines, and Madagascar's rosy periwinkle plant, which is used in certain cancer drugs. Phytopharm, a UK company, recently patented P57, ingredient in the hoodia cactus found in Africa's Kalahari desert, and then sold the rights to license the drug to Pfizer. The report urges that patents on plants and crops for food and agriculture should be banned under TRIPs – which was primarily drafted with corporate interests in mind and failed to reflect the legitimate concerns of the poor. Control over crops, plants and their DNA is one of the defining issues of the early 21st century. It will determine who wields power over farming and the global food system.

(***Source:*** *Financial Times*, October 25, 2001)

Vote allows EU to fund stem cell research

The European Union should be allowed to fund research into the use of human stem cells, but money should not go towards human cloning for reproductive purposes or the creation of embryos for research. Broadly backing European Commission proposals for the EU's Euro 17.5 bn (£ 10.7 bn) 6th Framework research programme, due to start in 2003, the parliament rejected attempts by some members, primarily Christian democrats and greens, to establish much more restrictive criteria for genomic research. The European Commission has singled out genomics and biotechnology as a priority for its 6th research programme, because of their potential for providing cures for a range of diseases such as Alzheimer's Parkinson's and cardiovascular ailments.

However, the proposal coincides with a heated debate both within Europe and beyond about the ethical dimension of this type of research. In a highly controversial decision, President Bush has already set out limits on federally funded research into stem cell lines. The Commission opted to set very clear parameters for the type of projects that could benefit from the around Euro 2bn earmarked for research into genomics and biotechnology for health. It proposed that EU money should not be used for projects involving the creation of embryos for research purposes, nor for reproductive human cloning or research aimed at changing people's inherited genetic characteristics. The parliament, which shares responsibility for approving the programme with research ministers, broadly backed the approach yesterday in its first vote on the issue, but called for additional money to broaden scientific investigations into animal and plant genetics. Ministers are expected to adopt an initial position on the proposals soon..

(***Source:*** *The Financial Times,* November 15, 2001)

Europe reverses position to support biotechnology

The European Commission recently issued a manifesto in favour of biotechnology and called for stronger backing for a sector seen as critical to future competitiveness. The communication proposes adopting "the highest standards of governance" to win over a skeptical public.

Biotechnology will be the next wave of technological revolution after information technology. The Commission recognized that they have a choice of accepting "a passive role, reacting to developments elsewhere, or develop pro-active policies to exploit the potential in a responsible manner consistent with our societal values". The Commission also acknowledged that Europe's biotechnology industry is lagging behind the US. To reap the benefits of life sciences and biotechnology, the Commission formulated a comprehensive strategy proposal, which focused on 4 main areas:

Area 1: Focus on education and research; develop entrepreneurial management skills in our enterprises to take advantage of the challenges ahead; develop risk capital sources that take into account the specificity of the sector; complete a coherent and accessible patent system.

Area 2: Need for a pro-active role for public authorities to monitor the impact on competitiveness and to anticipate emerging issues and adapt responsible policies. In addition, there is a need to continuously involve the public in the debate. The EU should complete the regulatory framework in the areas of GMOs and pharmaceuticals as soon as possible to ensure such confidence. Public trust in the role of science in our societies needs to be enhanced, also through better communication on EU regulation of these new technologies.

Area 3: The Community should continue to take a leading role in developing international guidelines, standards and recommendations. Europe has a particular responsibility to support the developing world, in particular, to ensure that they deal with the risks, challenges and opportunities that biotechnology brings.

Area 4: Regarding the implementation of this Strategy, the Commission will ensure implementation of the strategy and the action plan through: A regular Life Science and Biotechnology Report, including a rolling work programme for legislation. Europe is the principal consumer of Argentine corn. The de facto suspension was extended to all crops, including cotton.

(***Source:*** www.checkbiotech.org, October 02, 2001)

Bayer buys crop science for $6.6B, including debt

Germany's Bayer agreed on Tuesday to buy Aventis's agrochemicals unit for 7.25 billion ($6.6 billion), including debt. Bayer, Europe's second largest chemicals company, has been in exclusive talks with Aventis since July to buy the CropScience business, giving it a leading position in the $33 billion-a-year agrochemical market. Acquiring Aventis CropScience will make them a world leader in crop science and substantially boost Bayer's earnings power.

With 4 billion sales in 2000, Aventis CropScience employs about 15,300 people in more than 120 countries worldwide. Bayer will combine the unit with its exiting agrochemical business creating Bayer CropScience. The combined sales are expected to total between 6.5 billion and 7 billion in 2001.

Bayer (FBAY) will become the world's second-largest agrochemical company behind Switzerland's Syngenta. Aventis Crop Science is majority owned by Aventis, with a 24 per cent stake belonging to German drug maker Schering (FSCH). Bayer expects to take a restructuring charge of 500 million for the acquisition and estimated savings of 500 million a year. The acquisition is expected to be completed in the first quarter of 2002.As part of the agreement, Aventis will be responsible for any potential liabilities arising from the controversy over StarLink genetically modified corn, which had been approved for use in animal but not human feed. StarLink was found in consumer foods.

The moves is expected to come as a relief to Bayer's investors, who have seen their holdings pounded after Bayer withdrew in August of its cholesterol-lowering drug Baycol that has been linked to about 52 deaths.

Aventis, the Franco-German drug maker, unveiled plans last November to narrow its focus on pharmaceuticals by selling its slow-growing agricultural products unit. Rivals of Aventis, which was formed in 1999 by the union of France's Rhone-Poulenc and Germany's Hoechst, have already separated their farm-chemicals businesses to trade as separate companies. Anglo-Swedish AstraZeneca and Swiss drug firm Novartis floated their joint agrochemicals interests as a new company, Syngenta AG.

(***Source:*** www.checkbiotech.org, Oct 02, 2001)

Brussels puts forward biofuel plans for roads

Alternative fuels made from agricultural products would be the European Commission unveiled a compulsory component of motor fuels in the European Union under proposals. The proposals would ensure that, from 2005, at least 2 per cent of fuel used in transport came from biofuels, made from plant oils, sugar beet, cereals and even domestic waste. The mandatory minimum would rise to 5.75 per cent by 2010.

The Commission believes a shift towards biofuels would reduce the EU's growing dependence on oil imports, while generating less of the gases which contribute to the greenhouse effect. It would also offer new options to the Union's struggling farmers. However, the success of the package tests largely on a parallel proposal giving EU governments the option of reducing excise duties on pure or blended biofuels. This part of the package would require unanimous support from the 15 EU governments.

While biofuels have the advantage of being domestically made and less environmentally damaging, they remain expensive to produce. The Commission calculates the additional cost of biodiesel over conventional oil-based diesel at about —300 ($270) per 1,000 litres, with an oil price of $25 a barrel.

The proposals, which require the approval of EU governments and the European parliament, form part of the Commission's target of replacing 20 per cent of conventional fuels in road transport with alternatives by 2020.

The Commission is also aiming to boost research into the long-term feasibility of using natural gas and hydrogen and fuel cell technology in road transport. These are the other two alternative fuels it believes to have significant potential for growth over the next 20 years. The biofuels initiative mirrors efforts begun in the US in the 1970s under President Jimmy Carter to make greater use of bio-ethanol, primarily made from maize (corn). Europia, which represents most of the big oil companies in

Europe, said the proposals would not make a significant contribution to Europe's energy independence or to the environment, and cautioned against moves to make biofuel use mandatory.

Even environmental groups reacted cautiously to the plans, criticising the Commission for falling to differentiate sufficiently among the different types of biofuels, some of which they said would bring no environmental benefit.

(***Source:*** *Financial Times*, November 8, 2001)

Biotechnology groups despair at EU attitudes

European biotechnology companies are wondering what would happen if the European Union finally start approving genetically modified crops ,after EU environment ministers last month spurned the European Commission's latest effort to get the long-stalled authorisation process moving again.

No new genetically modified crops have been approved in the EU for more than three years. Last month, ministers made it plain that proposed new rules on labelling and tracing modified ingredients will have to be in place before they will consider lifting the block. This could take as long as three years.

While delighting the environmentalists, who have run a highly effective campaign against such genetically modified foods, the impasse has angered the biotechnology industry, set Europe on a collision course with the US, and presented the Commission with a serious dilemma.

The Commission has ear-marked biotechnology as a key area for growth in the EU's oft-stated quest to become the world's leading knowledge-based economy by 2010.

Yet a hard core of EU governments had declared a voluntary moratorium on new modified crop approvals, fearing a consumer backlash from the perception that foods derived from such crops pose potential health risks. European attitudes to food safety have hardened following a number of scares, most notably mad cow disease crisis.

Evidence of danger to human health is scant. Opponents of modified foods most often point to the US case of the corn StarLink, developed by Aventis, which was linked to several complaints alleging serious allergic reactions. However, StarLink was approved only for animal feed and found its way accidentally into some products.

Commission officials insist that genetically modified products face much more stringent pre-release testing than conventional crops. They point out that consumers happily swallow pills developed using biotechnology, while spurning foods derived from modified crops.

There is much at stake. In a recent report, the Commission highlighted the dangers of a brain-drain to countries, such as the US, where the business environment is far more favourable to the biotechnology industry and where R&D expenditure dwarfs the amount of money spent in the EU.

Biotechnology companies claim farmers are being deprived of new products that could give them a vital competitive edge and also point to the environmental benefits of modified cropos, which reduce pesticide and herbicide use.

Meanwhile, the US administration is coming under growing pressure from industry to act against the EU, on the grounds that its moratorium is illegal and prevents US farmers shipping to Europe varieties of corn and soya that have not been approved for EU use.

The US claims to be losing $200m in corn exports a year and some estimates put the additional cost to the US of applying new EU standards to bulk commodity exports at as much as $4bn a year.

The Commission also believes that the moratorium is illegal, as EU governments are refusing even to vote on approving 13 genetically modified crop varieties already cleared by the EU's own scientific advisers. Under the EU's regulatory system, the Commission is supposed to authorise any products once they are passed as safe if governments fail to take any decision.

But while it fears legal action from disgruntled biotechnology groups if it fails to act, it is also acutely aware of the public relations disaster if it chose to override the wishes of elected EU governments, particularly on an issue as sensitive as food safety.

The hard core of countries behind the moratorium – France, Italy, Austria, Denmark, Greece and Luxembourg – originally called for new rules on tracing and labelling modified foods a condition for ending their opposition.

A number of ministers stressed there could be no end to the moratorium before the labelling rules were on the statue book, a process which could take three years. France went further, suggesting there was a need for specific new laws on companies' liability for environmental damage caused by their products. All this leaves the system in limbo and the Commission facing the reality that EU governments are stifling an industry it has singled out for favoured status.

It's about time the member states acutally stood up and said whether or not they really want GMOs. They've got to stop using a science based safety system for political ends.

(***Source:*** *Financial Times*, November 10, 2001.)

Syngenta to pay Bayer $120 million in patent dispute

Syngenta, the world's largest crop protection company will pay Bayer the sum "in return for full access to crop protection and related markets worldwide." Neonicotinoid chemistry is used to produce Syngenta's thiamethoxam brands, which include Actara, Cruiser, Helix, Platinum and

Centric. Thiamethoxam's worldwide potential can now be fully realised particularly in the major agricultural markets. The decision pertains to a complex number of patent disputes in several countries, which have been running over several years and removes uncertainties, which had clouded international marketing efforts. The total sales volume for the Syngenta products using thiamethoxam could total over $400 million per year, a significant amount given overall sales of $6.9 billion in 2000. Bayer will continue to serve all markets with its imidacloprid-based insecticides Confidor, Admire, Gaucho and Calypso.

(***Source:*** www.checkbiotech.org, Jan 14, 2002)

Nigeria and other developing countries plead for labels on GM foods

Nigeria has asked Canada and the United States to label the genetically modified foods they export, saying that it would not be able to cope if the foods prove dangerous. Noting that many scientists are worried that the human food supply could be contaminated by the proliferation of genetically modified crops. Therefore, Nigeria has suggested to introduce strict labelling rules quickly. If it ever turns out that GM foods do present a health hazard, African nations will be hardest hit. In the meeting some other developing nations, particularly India, echoed Nigeria's impassioned push for comprehensive, mandatory labelling of all GM foods. However, nations that produce such foods notably, Canada, the United States and Argentina — stalled progress toward an international labelling agreement during the meetings.

Canada, which has chaired the meetings annually since the mid-1990s, cut off the labelling debate early in the afternoon, promising a longer debate at the next meeting, a year from now in Halifax. This year's conference began on Tuesday and runs until tomorrow, but yesterday was the only opportunity to debate the labelling of GM foods. Progress on the issue has been incremental since the mid-1990s.

(***Source:*** Genet, May 7, 2001)

China requires food products to list genetic alterations

As the global debate over the benefits and safety of genetically modified food rages on, China has passed regulations that require clearer labeling of these types of products. China's State Council considered and passed the Regulations Concerning the Biotechnology Safety Management of Agricultural Gene Alteration . The key problem in the biotechnology safety management of China's agricultural gene alteration is that when agricultural products with genetic alterations are made into food, there is no label indicating that it is food with genetic alterations. As a result, consumers cannot make the right purchasing decisions on their own.

In the past, when crops with genetic alterations graduate from the laboratory to the field, they had to be approved by the Ministry of Agriculture. However, when they were transformed into merchandise, there were no such regulations. The new legislation will regulate the biological products with gene alterations requiring the above-mentioned food labeling, for example, so that the issues related to gene alteration can meet international standards. Some countries often ban the import of certain food products on account of the gene alterations, but some countries will not. Now that we have the proper labels, they can make their own decisions.

(***Source:*** Genet, May 16, 2001)

China: MOA assesses the impact of biotechnology regulation

China recently issued a regulation on the management of genetically modified organisms that could have a substantial impact on soybean imports. Among other things, the regulation will require safety certification of all domestic and imported GMOs, and labeling of GMOs and processed products containing GMO materials. Just how much impact this regulation will have on trade will depend on the implementing regulations. These are now being drafted by the Ministry of Agriculture. The MOA website's analysis and forecasting department recently published its own appraisal of the impact that restricting GMO imports would have on China. While some of the details and analysis are different, their conclusions are similar to those of Post.

Japanese food industry will not buy GE wheat from the US

While North Dakota legislators recently debated the pros and cons of restricting the production of biotechnology wheat in this state, the chairman of the North Dakota Wheat Commission was in Japan discussing the market implications of commercializing biotechnology wheat. Berthold, N.D., wheat grower Alan Lee was one of five U.S. wheat industry representatives who traveled in Japan to meet with representatives of the Japanese Food Agency and leading milling companies. Discussions with the Japanese industry leaders reinforced the cautious and conditional approach that has been endorsed by U.S. Wheat Associates and the National Association of Wheat Growers with regard to the introduction of biotechnology wheat. The message was clear that Japanese consumers are not ready for biotechnology wheat. Japanese milling industry leaders told the U.S. team that they would purchase wheat from U.S. competitors if in the future the United States cannot ensure that Japan will receive biotechnology-free wheat.

The U.S. team stressed that no wheat varieties derived from biotechnology are expected to be commercialized in the United States until 2003 to 2005. The Japanese industry leaders indicated they don't oppose biotechnology, per se - in fact, many recognize its potential. All of the industry leaders urged us to first work towards getting the release of new products derived from biotechnology that have consumer and processing benefits. This should help in gaining consumer acceptance. Japan enacted a new law April 1 that requires that any foods containing genetically modified products to be labeled as such. Japanese consumers have a high level of distrust in genetically modified products as a result of recent food safety issues in Japan. The U.S. delegation found that the Japanese millers were very aware of the legislation that had been proposed in North Dakota to restrict the production of biotechnology wheat. Instead, the North Dakota House of Representatives concurred with the Senate version of the bill while the team was in Japan. The bill now calls only for a possible study of issues surrounding biotechnology. The Japanese were appreciative of the visit by U.S. officials in advance of the potential release of biotechnology wheat and of the candid discussions that took place. Seiji Terada, USW country director in Japan, arranged for the team's visit and coordinated the meetings with key industry representatives. The team outlined the USW-NAWG position statement on biotechnology as well as the actions that the national wheat organizations are taking in anticipation of the eventual commercialization of biotechnology wheat. USW and NAWG are urging technology providers to obtain international regulatory approval and to ensure customer acceptance prior to commercializing biotechnology wheat.

They are also requesting that an identity preserved (IP) or closed loop system to be developed to prevent the commingling of biotechnology and non-biotechnology wheat. There is skepticism about the reliability of an IP system, but the Japanese millers agreed to work with a U.S. industry advisory committee to review a system being proposed by Monsanto. The company is preparing for the launch of "Roundup Ready" wheat, which is resistant to its leading herbicide. Even with a viable IP system, Japanese millers emphasized that their wheat import costs would likely increase because of new mandated labelling and testing requirements. Flour millers expressed very strong objections to absorbing any increased costs. In addition to North Dakota's Alan Lee, other members of the U.S. delegation were Darrell Hanavan, chairman of the USW/NAWG biotechnology committee and executive director of the Colorado Wheat Administrative Committee; Nelson Denlinger, vice president of U.S. Wheat Associates, and Barbara Spangler, executive director of the Wheat Export Trade Education Committee, both of Washington, D.C.; and Mike Bruer, vice president of the Minnesota Association of Wheat Growers.

(***Source:*** Genet, May 8, 2001)

China second to US in GM plant research

A recent survey participated in by 80 per cent of China's plant biotechnology research laboratories showed that the country has the largest plant biotechnology capacity outside of the US. The study also revealed that China is focusing on improving food crops such as disease or drought resistant rice, wheat and potatoes, which have been mostly ignored in the laboratories of industrialized countries. Out of the total field trial acreage, more than 90 per cent target insect and disease resistance in crops. Some of the benefits gained by Chinese farmers in using GM crops include reduction in pesticide use and increase in production efficiency.

The research team of Jikun Huang, Scott Rozelle, Carl Pray and Qinfang Wang who conducted the two-stage survey in 2000 note that many competing factors are putting pressures on policy makers to decide whether or not to continue commercializing transgenic crops. The current size and rate of increase of research investments, and past success in developing technologies suggest that products from China's plant biotechnology industry will one day become widespread in the country.

As of 1999, China has already put an estimated $112 million to plant biotechnology research most of which are solely funded by the government. Furthermore, China's officials announced that it would raise the budget for plant biotechnology research by as much as 400 per cent before 2005.

Since 1996 till year 2000, the Chinese Office of Genetic Engineering Safety Administration approved 251 cases out of the 353 GMO applications. Approval was given to 45 GM plant applications for field-testing, 65 for environmental release, and 31 for commercialization. The study identified more than 50 plant species and more than 120 functional genes which scientists have used in their plant biotechnology research.
A full copy of the report can be downloaded at http://www.sciencemag.org/

(***Source:*** www.checkbiotech.org, May 10, 2001)

China offers insights to Syngenta seed business

When Jeffrey Beard saw his seeds business drop in the US last year, he looked across the Pacific Ocean to China, and discovered a dilemma more familiar to multinationals in manufacturing than agriculture. As head of the seeds operations at Syngenta, the world's biggest agribusiness company, Mr Beard could only watch as his Californian customers, and his own sales, were being swamped by a wave of cheap Chinese vegetables. An insight into China's rising importance in global agribusiness and its impact on companies such as Syngenta, can be found in Shouguang, the heartland of China's vegetable business, in Shandong province.

It was here in late April that Syngenta launched a new mainland base, selling its products and training local farmers in everything from choosing and planting seeds to the use of water and pesticides. The site of China's largest wholesale fruit and vegetable market, it is also the base for the mainland's export drive in primary produce - a cause of trade friction with Japan.

Shouguang is a showcase for Chinese agricultural-innovation, such as the indigenous greenhouses called "sunny houses" - long enclosures with curved, earthen roofs covered with straw overnight to conserve heat. The sunny houses have helped China claim the position of the world's number one vegetable producer, with an output valued last year at USDollars 42.27bn, according to figures released by the Agriculture Ministry in April.

Syngenta's Shouguang operation, including a small, 10ha demonstration farm, will act as a kind of listening post for the Swiss company in the Chinese market. On the face of it, the world's biggest agribusiness company and the most populous farming production would seem a natural fit - especially in genetically modified food.

Syngenta has a high profile in Chinese agribusiness circles following its announcement in January that it had mapped the genome of rice, the country's staple crop. China's government, which faces an enormous challenge in both feeding and supporting its 800m-strong rural population, has been more open to GM crops than just about any other country.

While western nations run political campaigns to make their protests heard, there is no room for GM critics in China. While Syngenta is not giving away its map of the rice genome, the company is providing some information through academic collaboration agreements. China's interest in GM crops has another, more practical element. China not only has 22 per cent of the world's population and 7 per cent of its arable land, but also 40 per cent of the globe's farming population. Syngenta, and competitors such as Monsanto, have been encouraged too by the recent passage of China's first seeds law, which provides a framework for protecting the companies' proprietary genetics.

It is China's small farms, however, which on average measure just 0.1ha-0.2ha, that provide the largest obstacle to a competitive agriculture sector and to companies such as Syngenta making money. Cost-effective measures such as bulk-selling are out, for example. Seeds come in small packets and pesticides in bottles rather than large drums. And as long as the farmers do not receive a better price for their produce, there is little incentive for them to buy Syngenta's seeds and fertilisers.

However, it is crucial that farmers learn from their western counterparts if they are to reap rewards. Syngenta's "Farmer Support Team" – Chinese agronomists who offer free classes in crop protection - say local farmers currently waste fertilisers and have little idea about combating crop diseases. Most farmers have a low education, they have a lot of experience in planting vegetables, but they have no idea of the theory behind it. Syngenta must now find ways to make it worth their while to learn.

(***Source:*** www.checkbiotech.org, May 10, 2001)

Japan to start mandatory checks for GM feed

Japan's Agriculture Ministry will introduce mandatory safety checks to guard against imports of unapproved genetically modified (GM) crops for animal feed, following a recommendation by a government panel.

The ministry said in a statement the 10-member panel of experts had proposed setting a framework to measure acceptable levels of GM content since a zero-tolerance policy would be difficult to implement. If the new rules are completed, the government can impose a ban on unapproved gene-altered products or order recalls of the products. Currently, the ministry can only ask domestic importers not to import unapproved GM products for animal feed use through administrative instruction. Details of the new rules, including the standard of testing and the level of tolerance, are subject to further discussions.

The move by the ministry, which oversees animal feed products, follows stricter legislation setting zero tolerance for food imports containing unapproved gene-spliced products that took effect from April 1. The Health, Labour and Welfare Ministry has begun checks for StarLink biotechnology corn in food imports at unloading ports and in domestic food products. StarLink was found last October in food products in Japan, where it is not approved for food or animal feed use, prompting the single biggest U.S. corn buyer to sharply cut its buying and to find other supply sources. StarLink was barred by U.S. regulators for human use because of concerns it might cause allergic reactions. The discovery of the gene-altered corn in taco shells last September triggered the eventual recall of more than 300 U.S. foods.

Japan imports 12 million tonnes of corn each year for animal feed and another four million tonnes for food. The United States supplied more than 95 per cent in 2000.

(*Source:* www.checkbiotech.org, April 20, 2001)

Japanese drug company cut profits, hike spending on genome R&D

Japanese drugmakers are boosting spending on genome research and sacrificing short-term profits, in a bid to catch up with western pharmaceutical giants in the search for materials for new drugs. Japan's No 2 drugmaker Sankyo Co Ltd and No 3 Yamanouchi Pharmaceutical Co Ltd are set to more than double spending on genome research and development (R&D) over the next three to five years, while rival Eisai Co Ltd plans to double genome research staff in the next two years.

The moves, which come amid a genomic-based drug discovery race worldwide, are aimed at finding suitable targets for new blockbuster medicines and reflect Japanese companies' concern they are lagging behind in the tailor-made drugs area. Genome-based research is expected to lead to an explosion of cutting-edge new drugs over the longer term.

Japanese drugmakers have trailed behind western rivals in investing in genome research, partly due to complacency over stable earnings growth despite the nation's prolonged economic slump. But the recent drives by foreign rivals such as Eli Lilly and Co and Bristol-Myers Squibb to reinforce their bases in Japan – the world's second-largest market – have heightened Japanese firms' concerns.

(*Source: The Economic Times,* June 14, 2001)

Thai jasmine rice

Thailand needs to take a stand to prevent US companies from genetically developing Thai jasmine rice and them patenting it as its own. The Thai government must urgently join forces with other interest groups and prevent the United States from developing Thai jasmine rice and claiming it as its own produce. As a US genetics expert was growing a rice strain almost identical to Thailand's popular top-quality jasmine rice in Florida, something once considered impossible due to climate.

The breeding breakthrough comes in the wake of another coup by United States, a Texas company has successfully won approval to patent certain varieties of long-grain aromatic Basmati rice traditionally grown in the Himalayan foothills. The company beat off a challenge by India to win the right to patent its own basmati-like brands, sparking protests from Indian lawmakers who feared the country's export of 650,000 tonnes of Basmati rice each year would be affected.

(***Source:*** *The Economic Times*, October 8, 2001)

Thai PM to raise rice issue in Washington

When Thailand's prime minister, Thaksin Shinawatra, meets President George W. Bush during his four-day visit to Washington this week, he is expected to raise a matter that has aroused almost daily protests from Thai farmers: the development of a "jasmine" rice variety at a US university. The aromatic jasmine variety has been bred and nurtured by Thai farmers over centuries, becoming vital for many farming communities.

Thailand, the leading rice exporter, is expecting a large crop this year: 7.3m tonnes, up from 6.6m tonnes last year. Of this, 2m tonnes will be jasmine rice, which commands a premium price.

University of Florida researchers are using the genetic data of the jasmine seeds to try to produce a short-stem, early maturing variety that would make it suitable for US rice growers. The university recently extolled the potential for jasmine rice production in the US, based on breeding work with Thai varieties.

But non-governmental organisations suspect Florida's researchers of "biopiracy". Biodiversity Action Thailand (BioThai), an NGO working to protect biodiversity and farmers' rights, has suggested the samples may have been smuggled out of Thailand illegally. Almost 500,000 tonnes of Thai jasmine rice will be exported to the US this year for about $300m. Thai farmers fear the loss of this market if the US develops its own jasmine. They would also face stiffer competition for exports elsewhere. Research samples of jasmine seeds are held by IRRI for safe-keeping under a United Nation's Food and Agriculture Organisation. This prohibits intellectual property claims on the trust's collections. No patent has been applied for on jasmine rice but Thai farmers fear that one may be coming.

(***Source:*** *Financial Times*, December 13, 2001)

Statement on biotechnology from the Bangladesh, Ministry of Science and Technology

Biotechnology is the cutting-edge of science. The tools of Biotechnology are poised for both a challenge and tremendous opportunity for growth and development of mankind. The world is facing over increasing and tremendous challenges of hyperbolic growth of population, environmental degradation including loss of Biodiversity at alarming rate, deforestation and desertification and depletion of natural resources.

With the development of biotechnology there arise great hope and aspiration to use this tools of genetic engineering & biotechnology to boost the world food production aiming at food security as well as to enhance the quality of life through sustainable agriculture practice and sustainable use of other natural resources.

(***Source:*** Muhammad Noor Uddin Khan, Minister, Science & Technology, Bangladesh)

South East Asia (SEA) to field test GM Papaya in 2002

Papaya production used to be a lucrative business in South East Asia (SEA) before crops were devastated by papaya ringspot virus (PRSV) and aggravated by post harvest problems. Now there is good news for small farmers in Southeast Asia as several countries are working at developing local papaya cultivators that solve these constraints. Malaysia is expected to test its delayed ripening papaya while Thailand will test its papaya ring spot virus (PRSV) resistant crop in field trials next year.

To address the problems of papaya, the *Papaya Biotechnology Network of SEA* was formally launched with the primary objective of enhancing income generation, food production, nutrition, and productivity for resource-poor farmers by integrating proven biotechnology applications into their agricultural practices. In the near term, the network seeks to positively impact the lives of farmers in South East Asia by increasing the availability of papaya for both food and modest incomes.

The network is composed of experts from Indonesia, Malaysia, Philippines, Thailand and Vietnam. The International Service for the Acquisition of Agri-biotechnology Applications (ISAAA) developed and facilitated the project with support from the public and private sectors. Monsanto and scientists of the University of Hawaii are collaborating with the network to develop PRSV resistant papaya while the former Zeneca Plant Science, now part of Syngenta, and the University of Nottingham are sharing their technology and know how on delayed ripening in papaya.

Randy Hautea, ISAAA Global Coordinator and SEA Director, says that through the network, SEA researchers are now working at developing local papaya cultivars that are resistant to PRSV and have delayed ripening traits. In a few years time, they hope to produce local papaya varieties suited for each country and make them available for small-scale farmers.

The network members are collectively addressing the critical aspects of product development, effective biosafety and food safety regulations, product dissemination, and product acceptance by growers, consumers and the general public. ISAAA recently organized a workshop in Vietnam among the network researchers. Technical presentations on papaya breeding and agronomy were done at My Tho, Vietnam by papaya experts Nguyen Minh Chau of Vietnam, Violeta Villegas of the Philippines, Chan Ying Kwok and Raveendranathan of Malaysia, and Robert Paull of USA.

Participants then moved on over to Hanoi, Vietnam to present country reports and plan future activities. They also visited papaya fields in neighboring districts.

IP/TT management network of Southeast Asia set up

The Intellectual Property/Technology Transfer (IP/TT) Management Network of Southeast Asia was formed last October 26, 2001 in Hanoi, Vietnam by researchers and research administrators from Indonesia, Malaysia, Philippines, Thailand and Vietnam. The core members of the network are those involved in ISAAA-facilitated technology transfer projects in Southeast Asia who had undertaken training under the ISAAA IP/TT Initiative in collaboration with Cornell University.

A recent external review of the ISAAA IP/TT initiative made a major recommendation that "ISAAA should respond to the request of partner countries to shift the focus of its IP activities to Southeast Asia" where the need is greatest. Consistent with the new institutional strategy of ISAAA, "this will place the IP center of activity in the developing countries of Asia", and help "develop their own capacity to deal with matters pertaining to intellectual property and technology transfer for use in agricultural production".

The Network aims to contribute pro-actively in the development of IP/TT Management in the SEAsian region, and eventually to other countries in Asia, Africa and Latin America in an initiative aimed at South-South sharing of appropriate knowledge and experience on IP/TT management. The Network identified several projects to undertake in order to address the IP/TT management challenges and constraints identified by the different countries.

The Network has designated Dr. Tanit Changthavorn of BIOTEC-Thailand as first Network Coordinator while the following will serve as Country Coordinators: Dr. Tantono Subagyo - Indonesia, Dr. Peng Fatt Lam - Malaysia, Dr. Reynaldo V. Ebora - Philippines, Ms. Nutina Netsuwan -

Thailand and Ms. Le Thi Thu Hien - Vietnam. Dr. Sutat Sriwatanapongse, Ms. Darunee Edwards (BIOTEC-Thailand) and Dr. Randy Hautea (ISAAA) will serve as Network Advisers.

Network membership is open to all researchers, research administrators, technology managers and individuals or institutions in Southeast Asia involved in IP management and technology transfer activities. Information and news about the Network will be regularly posted in the Knowledge Center Newsletter published by ISAAA as well as its website (http://www.isaaa.org).

For more information on the IP/TT Network of Southeast Asia, please contact Dr. Tanit Changthavorn (tanit@biotec.or.th) Dr. Reynaldo V. Ebora (r.ebora@isaaa.org) or Dr. Randy Hautea (r.hautea@isaaa.org).

Agriculture growth slows down in Southeast Asia

Agriculture growth in Southeast Asian countries barely increased 0.2 per cent on the average for the year 2000 from a 3.7 per cent expansion in 1999, data from the 2001 Asian Development Outlook (ADO) show. The report included the countries of Cambodia, Indonesia, Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam. The 0.2 per cent average growth of the region did not include Myanmar because its farm output growth was yet not available before the ADO was published.

Only Lao PDR, Vietnam, Philippines, Indonesia and Malaysia registered growths in agriculture output. Among them, only Malaysia achieved higher growth in 2000 while the other four countries were 1 per cent to 3.2 per cent short of their growth pace in 1999. Also, the expansion of agriculture output lagged in all eight countries in 2000, with the industry or the service sectors leading the Southeast Asian countries' economic growth. In 1999, agriculture in Lao PDR, Philippines and Indonesia led the growth of their economies.

Lao PDR listed the highest growth in the region at 5 per cent, a downtick from 8.2 per cent increase in 1999. Almost half of Lao PDR's gross domestic product (GDP) comes from the agriculture sector. The sector benefited from the country's investment in irrigation from 1997 to 1999. Lao PDR and Vietnam were the only countries that posted continuous growth from 1995 to 2000.

Vietnam managed a 4 per cent expansion in agriculture output despite the floods that negatively affected crops in the central and southern regions of the country and drought in the northern part. Vietnam was not spared from the regional slowdown. Its 2000 growth failed to outperform the year ago improvement of 5.2 per cent, the highest in the period 1995-2000. The growth in output in 2000 was not totally maximized by the farmers as seen in the decline in their earnings due to low export prices, increase in transport cost and limited supply of credit.

Farm output in the Philippines grew by only 3.3 per cent from the 6.5 per cent upsurge in 1999. Last year was the second consecutive year that the agriculture sector expanded from a 6.4 per cent contraction in 1998 due to the La Niña weather phenomenon. While agriculture significantly contributed to the 3.4 per cent growth of the country in 1999, it was the sector that hampered overall domestic production in 2000. The Philippines, however, enjoyed a 4.4 per cent improvement in the service sector in 2000 and a 3.9 per cent uptick by the industry sector, from only 0.9 per cent the year before.

Indonesia's agriculture production grew by 1.7 per cent, not enough to surpass the 2.7 per cent in 1999. The year 2000 was also the second consecutive year that Indonesia achieved growth in its farm sector after suffering a contraction in 1998. Its output was affected by poor weather conditions, natural disasters and civil unrest in the country.

Malaysia managed to increase its farm output by a measly 0.6 per cent, higher than the 0.4 per cent improvement in 1999. The expansion was attributed to the moderate growth in palm oil production and sawn logs which offset the reduction in rubber output. Increased activity in the manufacturing sector, accompanied by stronger exports, propped up its GDP growth.

Singapore continued to register a contraction in its farm output for the third consecutive year. Its agriculture production further slid 1.5 per cent from 1.1 per cent decrease in 1999 and 6.9 per cent drop in 1998. The country is highly dependent on its industry and service sectors.

Cambodia, after enjoying three years of improvement in its farm output, suffered a 2.7 per cent decline in 2000. Severe seasonal flooding led to loss of crops. Poor performance by the forestry subsector also negatively affected the sector.

Thailand's agriculture sector was the worst performer in the ADO. Farm production dipped by 8.8 per cent from a 2.6 per cent increase in 1999. Excess flooding haunted the sector and damaged the crops.

(*Source:* www.checkbiotech.org, Oct 22, 2001)

Kenya: UN project launched to enable developing world to import GM

The United Nations has launched a US$38.4m project to enable countries in the developing world to import GM foods, a UN official revealed.

The UNEP-GEF Biosafety Project is culmination of two years preparation work, following on, from the Cartagena Protocol on Biosafety, which was signed by 107 governments in January 2000. Since then, however, only ten countries have ratified the Protocol, and for it to take effect another forty countries are required to do so.

The three-year project, which will be financed by the Global Environment Facility (GEF) and managed by the UN Environment Programme (UNEP), will aim to train officials and business people in around 100 countries to effectively implement the Protocol's provisions on the global trade of GM foods.

The UNEP headquarters in Nairobi is to host a three-day workshop until 18 January and involving 46 African countries. It is part of a series of over 20 workshops to be held globally.

(***Source:*** www.checkbiotech.org, January 17, 2002)

Annals of science: scientist seeks to copy jasmine rice

Plant Breeder Chris Deren is nearing the end of a quest that began nearly five years ago, inspired by his travels through Southeast Asia in the 1970s. He enjoyed the region's culinary delights, but the fragrant Thai jasmine rice – the pride of Thailand that is enjoyed by the aficionados worldwide – held a special place.

Fast forward to the present, and the genetics expert is growing the Thai rice in experimental plots at Everglades Research and Education Centre, something once considered impossible due to the local climate. His breeding breakthrough comes in the wake of another coup by the US rice industry. A Texas company has successfully won approval to patent certain varieties of long-grain aromatic basmati rice traditionally grown in the Himalayan foothills.

The company beat off a challenge by India to win the right to patent its own basmati-like brands, sparking protests from Indian law-makers who feared the country's export of 650,000 tonnes of basmati rice each year would be affected.

Deren's rice plants have cleared key obstacles that had made them unable to be grown in the United States. The original plants are late-maturing and need extended sunshine, factors that didn't match up closely enough with US rice areas.

Deren set about trying to develop rice plants that were early-maturing and shorter in stature through two processes, gene mutation and conventional cross-breedingDeren said the gene mutation method was expected to yield a germ plasma, somewhat of a working model, in about two years, which would form the foundation for any commercial production. Deren said some modifications might have to be made to the germ plasma to produce a crop suitable to local conditions. Whether it will be received well by the farmers is difficult to say. It might take years for a commercial variety to be ready.

Thailand, the world's top rice exporter, produces about three million tonnes of jasmine rice a year and about 24 million tonnes of rice in total. The country sells the staple to 120 countries, earning some $1.5 billion (Bt66.7 billion) annually. The United States itself imports about 300,000 to 400,000 tonnes of Thai jasmine rice a year.

(***Source:*** *The Nation*, Manila, September 29, 2001)

Document

The Benbrook Report is part of series being published by the Institute for Agriculture and Trade Policy (IATP), US and Genetically Engineered Food Alert, US, on economic and legal issues related to genetically engineered crops. Over the last six years, farmers who planted genetically modified Bt corn have lost $92 million or an average of about $1.31 per acre, according to the first farm-level economic analysis of the product. "When Does It Pay to Plant Bt Corn: Farm-Level Economic Impacts of Bt Corn, 1996-2001," is by Dr. Charles Benbrook of Benbrook Consulting Services. Dr. Benbrook previously served as the Executive Director of the National Academy of Science Board of Agriculture of US. A brief summary of the report is being given herewith for wider dissemination and generation of an informed debate on biotechnology.

Benbrook Report on Farm-Level Economic Impacts of Bt Corn, 1996-2001

Corn farmers have now planted over 70 million acres of Bt corn, genetically engineered to express Bacillus Thuringiensis (Bt) toxins in plant tissues for the control of two Lepidopteran insects, the European Corn Borer (ECB) and the Southwestern Corn Borer (SWCB). Farmers pay a significant premium for Bt corn varieties. But do increased yield benefits justify the added expenditure?

From 1996-2001, American farmers paid at least $659 million in price premiums to plant Bt corn, while boosting their harvest by only 276 million bushels – worth some $567 million in economic gain. The bottom line for farmers is a net loss of $92 million – about $1.31 per acre.

For each farm, the economics will differ depending upon the frequency of ECB/SWCB infestations, how widely the insects occur, insect population dynamics throughout their multi-stage lifecycle, and a whole host of biotic (like natural predators and corn plant defenses) and abiotic (cold weather and hard rains) factors. In this report, the first independent national evaluation of farm-level economic impacts, we boil down all these factors for the major corn producing states for 1996- 2001. Our methodology and assumptions were purposefully conservative to be sure to not underestimate the value of Bt corn.

One surprising finding emerges – the price of Bt seed can vary greatly. Some farmers have been paying a premium as high as $30.00 per acre for Bt corn (far more than the $8.00 to $10.00 "technology fee" typically charged), while other farmers receive discounts or price breaks that trim the Bt corn price premium to just a few dollars per acre. In some cases Bt corn seed is actually cheaper than several top-yielding conventional varieties.

The linkage between seed price and yield performance is hit-and-miss, especially in years or regions where ECB/SWCB populations do little or no appreciable damage to corn plants. Between the impact of varietal choice on yields and differences in seed costs, the selection of corn seed can and routinely does shift profits up or down by $20 to $40 per acre, and sometimes by as much as $50 or more per acre. In most years, good managers can limit yield losses with targeted spot applications of insecticides, longer rotations or strip-cropping systems that increase the population of insects that feed on corn borers.

The investment in Bt corn has, on average, paid off for farmers in three years (1996, 1997 and 2001), yet it has resulted in losses in another three

(1998, 1999, and 2000). It appears that Bt corn delivered the greatest net benefits in 2001, due largely to increased infestations of ECB/SWCB, but the 2001 data are preliminary. It lacks final corn production, market price, and ECB/SWCB data for some states.

Other key findings of the Benbrook report:

- The cash outlay for seed for a field where farmers decide to plant a Bt corn hybrid is about 30 to 35 percent higher than the cost of otherwise well-adapted conventional varieties. This increase in per acre seed expenditures is by far the biggest in history linked to a single new trait.
- On average farmers have harvested 3.9 more bushels per acre planted to Bt corn. It would have required more than another bushel yield bump, or 5 bushels per acre, for farmers' investments in Bt corn to pay off, on average, at the farm-level.

Farmers should keep in mind the following when making corn seed choices:

- The newest and most expensive varieties may not be the most likely to produce the highest yields, nor do lower-cost varieties lack the genetics to produce top yields.
- Well-tested, proven hybrids with traits matched to local soil, climate and agronomic conditions offer the least risk.
- Seed bargains will help maximize per acre profits, not yields. The quest for county yield records may come at the expense of profit margins.
- Comparison shopping for the right seed pays off. The most expensive Bt variety is over $50 more per unit than the least expensive Bt varieties.
- If new and costly seed technology seems promising, it may pay to test a new Bt variety in a small, representative production field alongside a closely matched conventional variety in the required non-Bt corn refuge acres to evaluate how well each does under various circumstances.

The Production and Economic Imacts of Bt Corn: Bushels of Corn Loss Avoided,Value of Increased Yield, the Bt Corn Premium, and Impact on Farm Level Profits 1996-2001

State	1996	1997	1998	1999	2000	2001	1996-2001
Colorado	369,200	2,246,149	5,477,784	6,811,740	6,240,780	6,027,840	27,173,493
Illinois	2,549,583	3,806,569	4,165,384	4,053,672	6,013,907	24,301,048	44,890,523
Indiana	276,438	820,573	995,390	5,230,579	3,016,440	5,056,819	15,396,240
Iowa	1,402,080	3,275,005	3,533,718	3,042,394	3,567,000	13,742,001	28,562,198
Kansas	283,227	888,071	1,035,368	923,832	932,880	3,881,196	7,944,574
Kentucky	139,707	355,056	306,811	900,900	484,120	1,146,880	3,333,474
Michigan	103,626	355,680	100,596	188,760	178,957	364,320	1,291,939
Minnesota	1,140,000	2,497,970	3,091,663	2,111,576	2,926,663	12,854,824	24,622,695
Missouri	739,555	1,218,781	1,344,871	1,393,982	317,950	1,468,800	6,483,940
Nebraska	1,685,493	4,974,442	2,723,418	3,108,040	5,569,200	14,710,800	32,771,393
New York	32,218	110,854	125,841	177,710	129,654	277,970	854,246
Ohio	93,240	409,106	295,849	1,147,608	614,739	2,275,416	4,835,958
Pennsylvania	13,114	46,178	59,319	56,700	97,441	133,950	406,701
South Dakota	897,867	1,416,606	1,719,979	2,107,224	3,385,648	8,873,304	18,400,628
Texas	611,520	3,895,545	7,683,624	9,810,450	9,478,560	6,697,600	38,177,299
Wisconsin	305,454	880,610	262,152	1,045,044	944,378	2,120,294	5,557,882
Other States	746,435	1,648,085	2,357,586	1,636,252	2,698,088	6,339,178	15,425,624
U.S.Total	11,388,756	28,845,280	35,279,353	43,746,462	2,698,088	10,272,601	276,128,808
Dollar Value Added Yield	$30,863,529	$70,094,030	$68,441,944	$79,618,561	$86,203,258	$231,572,461	$566,793,785
Bt Corn Price Premium*	$11,690,000	$62,730,000	$144,720,000	$147,180,000	$154,250,000	$138,560,000	$659,130,000
Net Profit (loss) from Bt Corn	$19,173,529	$7,364,030	($76,278,056)	($67,651,439)	($68,046,742)	$93,012,461	($92,336,215)

† Average market prices per bushel of corn by year are reported in Table 3 of the full report. The Bt Corn Price Premium is from Table 8.

* Bt Corn Price Premium based on acres planted to Bt corn multiplied by the average technology fee in Table 12 of the full report.

Source: Benbrook Consulting Services, 2001

Conclusion

On average nationwide, from 1996-2001, yield increases due to Bt corn have not increased farm income enough to cover the higher costs of Bt seed. The bottom line for farmers is a net loss of $92 million – about $1.31 per acre.

Bt corn is no different than other new technology that increases production. The 276 million more bushels of corn moving through markets in 1996-2001 have had a ripple effect through the farm economy. The average price received by all farmers growing corn is marginally lower as a result of the greater supply.

International concern and controversy over Bt corn has also reduced export sales by hundreds of millions of bushels, increasing supplies in the U.S. and further decreasing prices from the levels they otherwise would have attained.

Six years is too short a period to take the full measure of any major new agricultural technology, especially one as novel and contentious as Bt corn. In all likelihood the farm sector will learn how to make more effective use of this technology and over time the price premium should narrow. The performance of Bt hybrids is also likely to improve as more back-crosses are made and experience is gained with transformed varieties.

However, it remains to be seen whether genetic resistance can be prevented in corn borer populations and whether physiological or soil microbial community problems will surface. No one can predict, either, whether world markets will warm to Bt corn.

Hopefully, lessons learned in the commercial introduction and planting of today's Bt varieties will help breeders develop the next generation of insect-resistant corn. Farmers, in particular, should pay closer attention to whether the next wave of "advanced" corn genetics is likely, in the end, to improve their profitability or shave another slice off per acre profit margins in order to generate the cash needed to meet Wall Street corporate profit expectations.

View the Entire Bt Corn Report at www.iatp.org

The complete report includes the following sections:

"The ECB Numbers Game" analyzes state-by-state corn borer infestation rates with basic calculations, equations and rules of thumb to guide farm-level planning;

"The Incremental Cost of Planting Bt Corn" compares average estimated costs of Bt to otherwise well-adapted conventional varieties, by acres and by state.

"The Performance and Price of Top Conventional and Bt Corn Hybrids" shows that there are real seed bargains out there, whether conventional or Bt, as well as several high priced varieties that perform irrationally;

"Farm-Level Economic Impacts of Bt Corn" quantifies the aggregate impact on farm-level profits by state and nationally.

*Much of the basic information in this report on the corn seed market comes from analysis of Doane Marketing Research, Inc. corn seed data covering 1998-2000. Doane corn seed data are reported by variety/company, type of variety, and Doane's "Maturity Group". (Doane analysts classify all corn varieties into one of eleven "Maturity Groups" based on relative maturity ratings). Doane corn seed data for 1998-2000 encompass 19,710 records, each representing a specific variety sold in one of the three years. Over this period, there were 15,384 conventional varieties sold, along with 2,320 Bt corn hybrids. There were, accordingly, 6.6 conventional varieties on the market for each Bt hybrid. The data purchased by Benbrook Consulting Services (BCS) includes acres planted, units planted (a "unit" is a bag of seed containing about 80,000 kernels, enough to plant 2.5 to 3 acres), average retail prices per unit, average discounts, and net prices (retail prices minus discounts).

Discussion on the Benbrook Report[1]

1. Introduction

On October 20, 2000, the Union of Concerned Scientists submitted to EPA a report prepared by Dr. Charles Benbrook analyzing EPA's assessment of the benefits of Bt crops.

The Benbrook report discusses the benefits of Bt field corn, Bt sweet corn and Bt cotton, with most of the discussion focused on Bt field corn. Benbrook concludes that although Bt field corn increases yields, these yield increases are modest and could be achieved easily by alternative techniques. He presents an analysis that is claimed clearly "to refute" EPA's conclusion that Bt corn has reduced insecticide use. His bottom line is that with relatively modest benefits, the relatively modest risks of Bt corn should tip the risk/benefit scales against the continued registration of Bt corn.

2. Summary of Critique

1. Benbrook concedes that, on average, Bt corn has improved yields and net returns. He argues that this is modest. 1998-2000 were years of very light insect pressure and low corn yields, and still, positive benefits were achieved. Many growers benefited far above the average. In heavy

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[1] www.checkbiotech.org, Oct 31, 2000.

infestation years the benefits will be much larger. With corn farmers in economic distress, a technology that improves the bottom line should not be dismissed.

2. The "alternative methods" that Benbrook favours are not new. They have been researched for 70 years. Farmers do not use them because they are extremely complicated, time consuming, would require extensive changes in farming practices and are not as effective as Bt corn.

3. Benbrook's pesticide use data to show an increase in insecticide use for the European corn borer is arbitrary and unconvincing. He leaves out of his analysis the one insecticide that clearly went down in use because of Bt corn. The insecticides that went up in use are not used for European corn borer (ECB) control. They are used almost exclusively for other pests. No entomologist or survey supports his hypothesis. The available surveys support the EPA conclusion that Bt corn caused a reduction in insecticide use.

3. Bt Corn

Benbrook claims that European corn borer management options are available. He asserts that ECB populations only reach damaging levels a few years out of every ten. Actually, the opposite is true. ECB populations are at damaging levels most years out of ten. Benbrook asserts that corn growers have been managing the ECB adequately most years without Bt corn. This is not accurate. Survey data from Iowa State University indicate that most corn growers were not managing the ECB at all. Some farmers harvested early to minimize losses to ECB.

Benbrook asserts that additional ECB control options are available for corn growers to use. He cites research at Ohio State University where researchers have studied ECB populations on organic farms in comparison with neighboring conventional farms. Benbrook reports that the Ohio State research suggests that differences in nutrient management results in less damage from ECB on the organic farm. Benbrook incorrectly interprets the Ohio State research as to the reason for less damage. Benbrook asserts that conventional farms with standard nutrient applications do not develop adequate defense mechanisms against the ECB. He suggests that organic corn develops defense mechanisms through more effective use of slower-releasing nutrients from manures and other organic types of nutrients.

Finally, Benbrook asserts that crop rotation is a “proven” control measure. This is totally inaccurate. There are no studies to support this. The ECB is highly mobile and flies between rotated and non-rotated fields. Benbrook uses tough language to describe research and technology that produce only modest improvements in crop yields. He suggests that society and agriculture might be better served by having the Bt corn researchers working on other problems. The same line of reasoning might be used to assess the performance of the considerable research effort regarding “alternative agriculture” over the past decade. What positive net benefits have they delivered? Where is the cost-benefit ratio concerning the Leopold Center, a sustainable agriculture research center in Iowa?

Benbrook claims that insecticide use for the ECB actually increased following the introduction of Bt corn. He cites no surveys of farmers who say that they have increased their insecticide use for ECB. He cites no university entomologists who share his view. The available surveys of farmers show just the opposite. According to Iowa State University surveys, insecticide usage among Bt corn farmers is declining. In 1996, insecticide use declined 13 per cent with Bt corn farmers. In 1997 and 1998, 19 per cent and 26 per cent of Bt corn farmers stated a reduction in insecticide use from previous years.

Benbrook’s logic in explaining why corn farmers increased spraying for the ECB is two fold. (1) Growers have been sensitized to the importance of ECB control because of all the attention focused on Bt corn. While this is a correct statement, Benbrook argues that some have decided that rather than planting Bt corn they would spray an insecticide. This makes no sense. Benbrook claims that the cost of the Bt seed is an extra $10 an acre; the cost of a single insecticide spray for ECB control is $14 an acre. Growers are advised to expect from 67 per cent to 80 per cent control of the ECB by spraying. Bt corn gives 95 per cent control. Why would a farmer decide to spray instead of planting Bt corn? Benbrook ignores all of the reasons that growers traditionally have not sprayed, including the difficulty of scouting and timing treatments. These problems have not disappeared. The decision to spray is not as simple as Benbrook implies. However, the decision to use Bt corn is simple. Given this increased interest in ECB control and Benbrook's assertion that alternative non-chemical methods are cost effective, why have the growers not selected a non-chemical method instead of spraying? (2) Benbrook also claims that beneficial insects may have shifted in importance because of Bt corn. There is no evidence to support this claim at all.

The data that Benbrook manipulates to support his ideas come from USDA NASS surveys of corn growers 1995-1999. Since the NASS data do not identify the target pest in the surveys, Benbrook makes his own assignments. He misattributes all of the spraying of lambdacyhalothrin, dimethoate and esfenvalerate to ECB. These pesticides are recommended for many insect pests in corn, including cutworm, stalk borers, leaf aphids, adult rootworm beetles, European corn borer, armyworm, grasshoppers and mites. There is no justification to assign all of their use to ECB. In fact, it is very likely that the increased use of these compounds is largely the result of increased in-season sprays for cutworms. Benbrook assigns 25 per cent of the increase in fipronil and bifenthrin to ECB control, with the remainder going to rootworm control. Bifenthrin is used primarily for mite control and not ECB. Fipronil was recommended in 1999 for rootworm and grubs. There is no mention in the University Extension publications for 1999 of ECB control with fipronil. Benbrook arbitrarily assigns 25 per cent of its use to ECB control.

Benbrook leaves one key insecticide out of his analysis of trends: foliar Bt, that was used on 1 per cent of the nation's corn acreage in 1995 and is no longer recorded as being used following the introduction of Bt corn. Why apply Bt foliarly when it is in the plant? Some farmers who report a decline in use of insecticides following the introduction of Bt corn undoubtedly were spraying Bt in the early 1990's.

Benbrook does not consider the likely impact of his recommendation that EPA cancel the use of Bt corn. He is correct in stating that growers have become sensitized to the potential damage from the European corn borer. Many growers have been ignoring the damage from ECB for many years and not spraying. Now they are planting Bt corn and seeing the positive impact on yields. What happens if Benbrook's advice is followed, and Bt corn is taken away? It is quite likely that insecticide use would increase dramatically as some growers start spraying. Benbrook cites entomologists who clearly advised growers to think long and hard about the potential benefits of Bt corn for 2000 based on the light infestations seen in 1998 and 1999. Their advice was only plant Bt corn if your experience over time indicates that you are likely to have a damaging population. This is sound advice.

Thus, the real question is who planted Bt corn and what did they gain by planting it? Averages can be very misleading. Data from Marlin Rice at Iowa State University indicate that benefits are not uniform. For example, in 1999, 21 per cent of the side-by-side comparisons in Iowa indicated a yield advantage for Bt corn of nine bushels per acre while the remaining 79 per cent indicated no advantage. In 1997, 40 per cent of the comparisons indicated an increased yield advantage of 18 bushels per acre for Bt corn while the remaining 60 per cent produced no advantage. There are growers who have made significant gains from planting Bt corn. Three factors must be kept in mind in evaluating Bt corn's effectiveness:

(1) It's early in the adoption cycle. Many growers may try out a technology to see how it works. They may stop using it if it does not produce significant benefits.

(2) Many growers may be willing to pay the premium for Bt corn seed simply for its insurance value. In case it is a bad outbreak year, they are protected.

(3) 1998/1999/2000 were very unusual years in that ECB populations were so low. A10 or 15 year time horizon may be needed to evaluate the technology fully.

Benbrook states that 1997 was a high infestation year. He is incorrect; 1997 was an average or slightly low infestation year. In a high infestation year the advantage of Bt corn could be as high as 40 bushels per acre.

Benbrook suggests that a positive net return of $3.31 per acre from Bt corn is modest and not important. He needs to be reminded of the extremely low returns that corn farmers have experienced these past few years. The $3.31 net return estimate is based on a Bt corn fee of $10 per acre. In actuality, the Bt corn fee has come down significantly and is probably closer to $7 per acre on average, that, essentially, would double the calculation of economic benefit of Bt corn to corn farmers.

4. Bt Sweet Corn

Benbrook reports that the planting of Bt sweet corn has been limited due to the unwillingness of shippers to accept the genetically engineered crop. He suggests that there might not be a huge reduction in insecticide spraying for sweet corn in Florida because of the emergence of the silkfly, that he asserts accounts for one-half of the insecticide use in the crop. This is an unsupported assertion. A University of Florida researcher presented data to EPA based on experiments in 1998 and 1999, documenting a reduction from as many as 19 sprays in the conventional sweet corn to 3 in the Bt sweet corn. Benbrook simply asserts that the silkfly is the result of intense spraying for other insects. There is no evidence for this, but if it were the case, would not reduced insecticide spraying in Bt sweet corn also result in more predators attacking the silkfly and perhaps further pesticide use reduction? Indeed, the University of Florida researcher presented data for the EPA Science Advisory Panel that showed that the numbers of predators and parasitic insects and spiders were all higher in the Bt sweet corn plots.

Benbrook bemoans the discontinuance of the insect resistance breeding programme for sweet corn in the 1970s. His implication is that further work with conventional breeding may have reduced the need for insecticides or for Bt sweet corn. This is not supportable. Sweet corn breeders have been focused on flavor and yield, and they have done a great job. What assurance can Benbrook provide that an insect resistant, conventionally bred sweet corn cultivar will also taste great? Keep in mind that the Bt sweet corn is insect resistant, high yielding and tastes great.

Benbrook mistakenly refers to methomyl as an organophosphate; methomyl is a carbamate.

5. Bt Cotton

Benbrook reports that EPA estimated a reduction of 7.5 million acre treatments in cotton as a result of Bt cotton, but he tries to put that reduction in perspective by suggesting that it may not hold up over time due to changes in pest populations, resistance, etc.

One value of Bt cotton is that it takes much of the pest resistance pressure from traditional insecticides for control of the bollworm/budworm complex (BBW), consequently prolonging their usefulness for other pests in cotton fields. Bt cotton is just another control technique for managing a complex set of pest problems in cotton. One sure way to help improve resistance management to Bt cotton would be to register more insecticides for cotton and keep currently registered insecticides available for cotton growers to use. One strong concern that Benbrook did not mention is that EPA may cancel many of the insecticides that cotton farmers use and put so much selection pressure on the remaining insecticides and on Bt cotton that resistance will appear more quickly.

He suggests that much of the reduction may not be due to Bt cotton because it initially occurred in 1996, following a heavy outbreak year in 1995. Bt cotton was introduced in 1996 and was planted widely in several states immediately (77 per cent of Alabama's cotton acreage). Sprays in Alabama for BBW went from 6.7 in 1995 to 0.1 in 1996. Bt cotton was responsible for this reduction. 1995 was a bad outbreak year because the 0chemicals were not effective enough.

Again, Benbrook manipulates NASS pesticide use survey data to try and associate certain chemicals with control of bollworm and budworm. He then asserts that based on his assignments, insecticide use for BBW actually increased in certain states (such as Alabama) from 1997 to 1999. He misattributes insecticides to BBW control. For example, the increase in Alabama is due to increased applications of aldicarb, a pesticide not targeted at bollworm/budworm, but one whose increased use in Southeastern states' cotton is accounted for largely by nematodes. Benbrook assigns tebufenozide and carbofuran as BBW insecticides; tebufenozide and carbofuran received emergency registrations for use against armyworms and aphids, respectively. There is no need for Benbrook to make the target pest assignments because cotton entomologists do such assignments every year, and the results are published in the National Cotton Council's Proceedings of the Beltwide Cotton Conferences. According to the Cotton Council's reports, in every state, sprays for BBW were reduced following the introduction of Bt cotton. Sprays for the BBW in Alabama did not double between 1997 and 1999, as Benbrook's manipulations suggest. Rather, the National Cotton Council's estimates are that between 1997 and 1999, there was a 20 per cent reduction in sprays for the BBW in Alabama.

Benbrook tries to put the reduction of cotton insecticide use in Arizona in perspective by suggesting that it may be due in large part to the introduction of new, effective insecticides for control of the sweet potato whitefly and not Bt cotton. There is no denying the positive impact of the new insecticides, but to give credit where credit is due, it is instructive, once again, to examine the National Cotton Council's estimates. For Arizona in 1999, conventional cotton growers sprayed once for bollworm; Bt cotton growers did not spray at all for the pest.

Bio Web

Selected Websites for Online Biotechnology Employment Resources

http://www.bioberufe.de/
http://www.forschung-und-lehre.de/
http://www.amplicom.com/hr.htm
http://www.vdbiol.de/firmen/
http://www.bio.com/hr/job/
http://www.biocareer.com/
http://www.biofind.com/jobs/
http://www.biotecjob.de/biotecjob/
http://www.biotecjob.de/
http://www.bioview.com/
http://www.callistogen.de/new.htm
http://www.acm.org/cacm/careeropps/
http://www.consultants.de/jobs/jobsuch/kondit-e.htm
http://www.bioscience.org/urllists/jobs.htm
http://www.gsf.de/cgi-bin/Stellenausschreibung
http://www.pharmajobs.com/main.html
http://www.isenseit.de/jobs.html
http://bioinformatics.org/news/jobs/
http://www1.infm.it/JOST/
http://www.joboptions.com/

http://www.opv.com/

http://www.bioplanet.com/employlinks.htm

http://www.hgmp.mrc.ac.uk/CCP11/jobs.txt.html

http://www. hgmp.mrc.ac.uk/CCP11/jobs_other.txt.html

http://www.medzilla.com/

http://www.nature.com/naturejobs/

http://www.biospace.com/b2/navigate/

http://www.bioplanet.com/chat/jobs/index.html

http://www.post-docs.com/

http://recruit.sciencemag.org/

http://jobs.uni-hd.de/

http://www.scijobs.org/

http://www.biotech-europe.de/Biotech/rubric/markt/job.html

http://www.symbiosinc.com/

http://www.symbiosinc.com/main.html

http://www.TheLabRat.com/jobs/index.shtml

http://www.c-und-q-bildung.de/v_assbio.htm

http://www.genomejobs.com/

http://www.jobs.zeit.de/

(***Source:*** *Bioinformatics,* (Bangalore) January 2001)

Status of Biotechnology in Singapore*

In recent past, Singapore has emerged as a major centre for biotechnology industry. It is addressing this frontier technology for growth in manufacturing sector. It is for this purpose that Singapore is diversifying into medical biotechnology. Singapore announced a fiscal package of $ 6.2 billion to stimulate manufacturing growth by supporting this diversification initiative in the sector. A large section of this is devoted to biotechnology. Singapore intends to enhance its industrial and technology base through greater focus on strengthening indigenous knowledge capability and training manpower in advanced technologies.

The last five year plan allocated US$ 1.2 billion for the National Technology Plan, thereby taking the total national R&D expenditure to reach 2.09 per cent of GDP by 2001. As is clear from Figure 1, the gross expenditure on R&D (GERD)/GDP ratio rose from 0.9 per cent in 1990 to 1.16 per cent in 1995 and 1.94 per cent in 1999.

The impact of this growing emphasis on domestic R&D is evident from the patenting activities, which continued unhindered. The number of patents applied reached 902 in the year 2000, up by 34 per cent from 1999, while the number of patents awarded grew to 285, up by 77 per cent from a year

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* Contributed by Gunjan Nagpal, RIS.

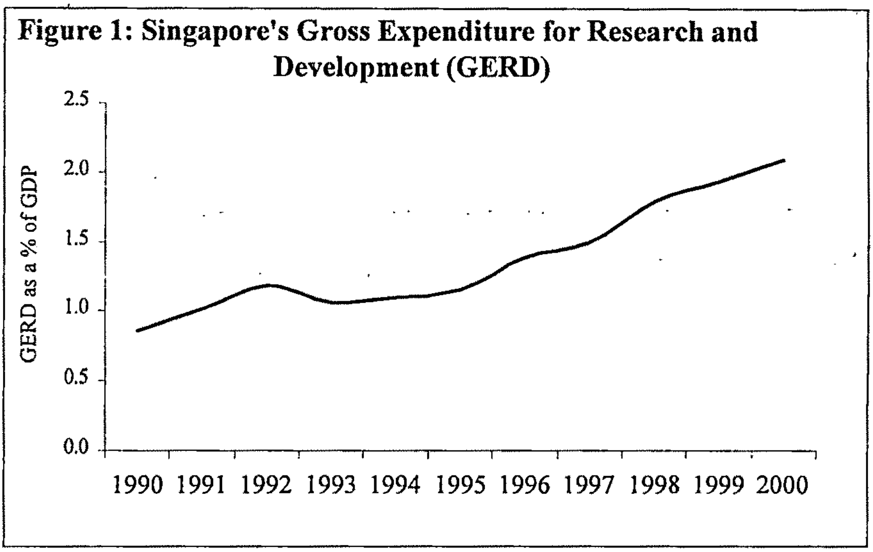

Figure 1: Singapore's Gross Expenditure for Research and Development (GERD)

ago in 1998 (Figure 2). This shows the increased awareness, by both private and public sector on the need to protect their intellectual properties arising from their research activities.

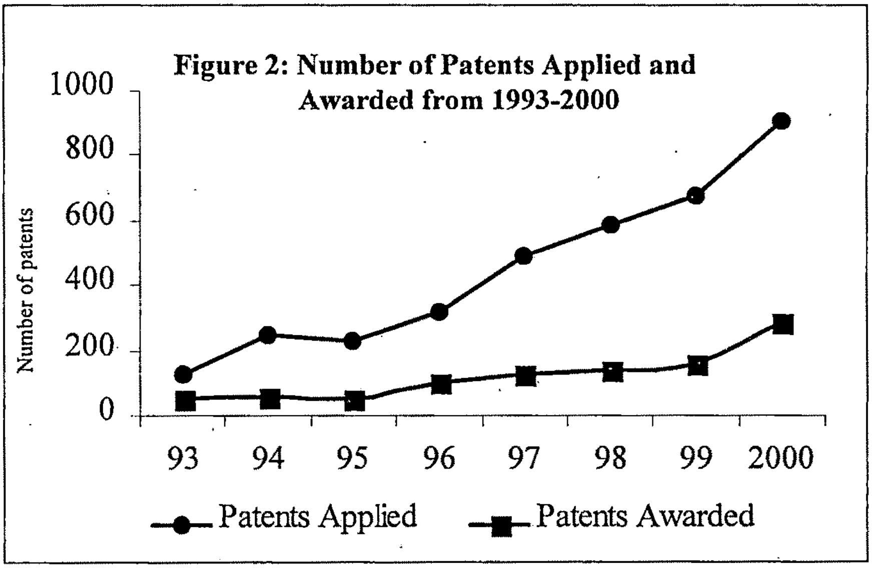

Figure 2: Number of Patents Applied and Awarded from 1993-2000

Table 1: Contribution of Bio Medical Science Industry in Manufacturing Sector of Singapore

		2000			1999	
	Manufacturing	BMS (%)	Share Sector	Manufacturing	BMS	Share (%)
Employment(No)	338,885	5300	1.56	338,885	5600	1.65
Output(S$M)	130.24	6.2	4.76	133.57	6.2	4.64
Value Added(S$M)	27.52	5.1	18.53	34.92	5.2	14.89
Establishment	-	-	-	3928	36	0.9
Workers	-	-	-	338885	5312	1.6
Direct Exports ($000)	-	-	-	85359764	7095476	8.31

Source: Industry Statistics (2001) Economic Development Board, Singapore.

Table 2 Foreign Companies' Share of Industry R&D Expenditure, 1997

Industry Group	(1) Foreign majority owned companies ($mn)	(2) Local majority owned companies ($mn)	(3) Total R&D Spending by Industry ($mn)	(1)/(3) %
MANUFACTURING	727.24	382.85	1110.09	65.51
Electronics	424.25	201.59	625.84	67.79
Chemicals	168.54	34.09	202.63	83.18
Engineering	94.78	113.92	208.70	45.41
Precision Engineering	74.62	74.2	148.82	50.14
Process Engineering	7.77	4.33	12.10	64.21
Transport Engineering	12.39	35.39	47.78	25.93
Life sciences	36.81	21.53	58.34	63.10
Light Industries/Other Manufacturing	2.86	11.72	14.58	19.
SERVICES	76.60	127.84	204.44	37.47
IT and Communications	47.69	86.85	134.54	35.45
Finance & Business	12.61	15.8	28.41	44.39
Other Services	16.30	25.19	41.49	39.29
ALL INDUSTRY GROUPS	803.84	510.69	1314.52	61.15

Source: 1997 National Survey of R&D in Singapore, National Science & Technology Board.

The Economic Development Board (EDB) of Singapore expects robust growth in the fields of pharmaceuticals, medical devices, healthcare services and biotechnology sector. As Table 1 shows, in the year 2000 the manufacturing output of biomedical sciences industry (BMS) grew by 2.1 per cent to S$6.4 billion and its value added grew by 2.7 per cent to S$5.2 billion. The share of BMS in the total manufacturing output grew from 4.64 per cent in 1999 to 4.76 per cent in the year 2000, which in value terms was S$131 million. Similarly, share of BMS in manufacturing value added sectors grew from 15 per cent to 19 per cent. The share of BMS in direct exports in 1999 was $709 thousands, which was almost 9 per cent of total manufacturing exports.

The table 2 shows the relative share of MNCs and domestic companies in R&D in Singapore. In case of life sciences, domestic companies have a share of 36 per cent in the total private sector R&D expenditure in Singapore which is very close or even higher than their share well established older industries in Singapore like chemicals (14 per cent) and electronics (38 per cent).

All the above tables indicate a major change is Singapore's approach to science and technology policy. Over the years, the status of biotechnology in Singapore has increased significantly.

ASIAN BIOTECHNOLOGY AND DEVELOPMENT REVIEW

May 2002

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- **Beijing Genomics Institute (BGI): A Report**

Research and Information System
for the Non-Aligned and
Other Developing Countries

Asian Biotechnology and Development Review

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The *Asian Biotechnology and Development Review (ABDR)* aims at generating wider awareness of the issues involved and emerging developments in the area of biotechnology. It hopes to serve as a forum of debate and dissemination of information on issues such as developmental potential of biotechnology, and the possibilities of South-South cooperation in this area. *ABDR* is a continuation of the earlier *RIS-BDR* series (Vol. 4 No. 3).

The cooperation and support received from the Life Science Section of UNESCO, Paris, France, and Department of Biotechnology, Government of India, New Delhi in bringing out this journal is gratefully acknowledged. However, they are no way responsible for the contents of the journal.

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Printed by: Multiplexus (India), 94, B.D. Estate, Timarpur, Delhi-110 054 (India)
Ph. 3818103, 3818775 & 3819438 Fax: 91-11-3810912 e-mail: multipxs@del3.vsnl.net.in

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BIOTECHNOLOGY AND DEVELOPMENT
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Biotechnology and Development: Challenges and Opportunities for Asian Region*

K.C. Pant**

Over the past two decades, new advances in frontier technologies such as Information Communication Technology (ICT), Biotechnology and new material sciences have thrown up many challenges not only for the science and technology experts in developing countries, but for policy-makers as well. Growth in biotechnology, in particular, has raised several hopes about its potential on the one hand and anxities about its implications on the other.

At this point, almost all the developing countries have recognized the recent advances in the field of biotechnology and the possible economic advantages that could flow from them. A large number of countries have already set up an elaborate institutional infrastructure to develop and diffuse this premier technology at various levels of agricultural and industrial production.

In the field of agriculture, biotechnology has given new tools for effectively ensuring food security for the developing countries. Several of these tools are being widely explored. This has become more relevant, especially as the Green Revolution varieties, widely used since the late 1960s, seem to have reached a plateau in terms of crop productivity. In order to protect and increase agricultural productivity, more sustainable agricultural techniques have been introduced, including conservation agriculture to conserve soil and water while reducing time and labour in land preparation, consuming less fuel, and reducing the need for chemical inputs.

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* Based on the inaugural address delivered at the "International Conference on Biotechnology and Development: Challenges and Opportunities for Asian Region" held on February 26-27, 2002 in New Delhi.

** Deputy Chairman, Planning Commission of India, and Chairman, RIS.

Another major success has been the development and adoption of integrated pest management techniques that have contributed to sustainable agricultural intensification while minimizing negative environmental impacts. By reducing the need for pesticide applications through the use of pest-resistant crop varieties, natural enemies and cultivation techniques, integrated pest management has increased the sustainability of farming and ecological systems at minimal cost. Another important challenge before policy formulating agencies across Asian countries is to create avenues for integration of traditional techniques like breeding processes and modern technologies for optimum economic gains.

In the field of medicine and pharmaceuticals too the potential of biotechnology is immense. Whether it is preventives, curatives or drug delivery systems, I believe there is a revolution in the offing. Surgical procedures and organ transplants may be easier and more affordable in the future with biotechnological techniques.

Biotechnology also offers new opportunities for global partnerships, especially between the countries rich in biological resources (which include genetic resources) but lack the expertise and investments needed to apply such resources through biotechnology and the countries that have developed the technological expertise to transform biological resources so that they serve the needs of sustainable development.

The success of the fourth ministerial meeting of the World Trade Organization (WTO), held in Doha in November 2001, in putting development at the centre of further trade negotiations, augurs well for the future of the trading system and the potential it offers to developing countries. One of the important issues which would be taken up at the next WTO Ministerial Meeting pertains to labelling of Genetically Modified Organisms (GMOs). This issue has attracted diverse opinion and has also generated a vigorous debate. In next few months this issue would be addressed at various international fora. In this context developing countries would have to do a lot of homework and prepare themselves for an emerging regulatory regime so that the trade interests of developing countries are not adversely affected. Moreover, one would also have to see compatibility between WTO trade agreements and commitments at other international fora. For instance, the Cartagena Protocol refers to advanced informed agreement while agreements on sanitary and phyto-sanitary measures (SPS) and technical barriers to trade (TBT) at the WTO still have to create scope for such provisions.

Most developing countries have yet to pass adequate legislations in this field of bio-safety. It is believed that they all need not only technical support to identify genetic manipulation, but also need financial support to upgrade their quarantine and other agencies to meet these challenges. In this regard, cooperation among Asian countries becomes very relevant.

In August this year, the international community would meet at Johannesburg at the World Summit on Sustainable Development, which would bring together thousands of participants, including heads of State and Government, national delegates and leaders from non-governmental organizations (NGOs), businesses and other major groups. They would focus the world's attention and direct action toward meeting difficult challenges, including improving people's lives and conserving our natural resources in a world that is growing in population, with ever-increasing demands for food, water, shelter, sanitation, energy, health services and economic security. As you all are aware, at the 1992 Earth Summit in Rio, the international community adopted Agenda 21, an unprecedented global plan of action for sustainable development.

The report from the Secretary General for Johannesburg Summit has rightly raised the concern that the financial resources required for implementing

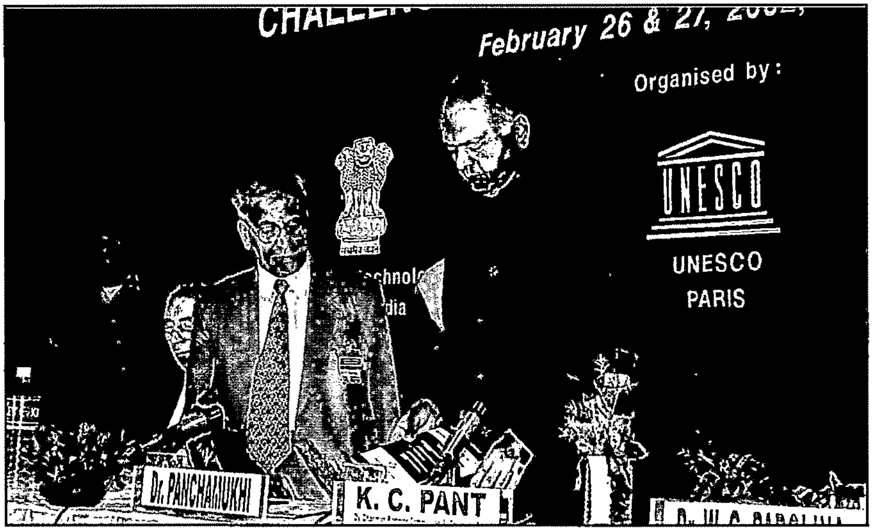
Agenda 21 have not been forthcoming and the mechanisms for the transfer of technology have not improved. Since 1992, official development assistance (ODA) has declined steadily, the burden of debt has constrained options for poor countries, and the expanding flows of private investment have been volatile and directed only at a few countries and sectors. Therefore, at this point, it is very important to evolve mutually coherent policies or approaches in the areas of finance, trade, investment, technology and sustainable development.

I would like to recall that Agenda 21 advocates various mechanisms to support access of developing countries to biotechnology and their rights over their own genetic resources. In this regard, Article 19 of Convention on Biological Diversity (CBD) becomes very relevant. It says, "Each Contracting Party shall take legislative, administrative or policy measures, as appropriate, to provide for the effective participation in biotechnology research activities by those Contracting Parties, especially developing countries, which provide the genetic resources for such research." It is against this background that I look forward to the deliberations and recommendations of this Conference with great expectations.

I am very glad that RIS has thought of extending its focus of work on biotechnology so as to involve Asian countries in a policy dialogue. RIS has a strong background of research and analysis in this field. It was way back in 1988 that RIS brought out a seminal volume titled *Biotechnology Revolution and the Third World: Challenges and Policy Options.* And subsequently launched *RIS Biotechnology and Development Review* in 1992 which now has been relaunched as the *Asian Biotechnology and Development Review (ABDR).*

I hope *ABDR* would act as a forum to deliberate on policy challenges before Asian countries in terms of governance, financing and adoption. While doing so, adequate insights from experiences of other regions/ countries may also be harnessed, so as to make diffusion a cost effective process.

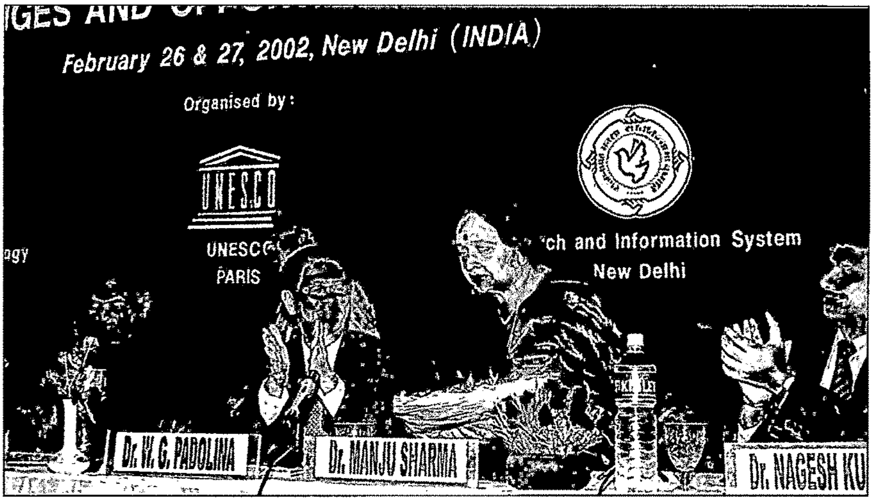
Launching of the *Asian Biotechnology and Development Review* at the International Conference on Biotechnology and Development: Challenges and Opportunities for Asian Region, New Delhi, 26-27 February, 2002



(Right): Shri K.C. Pant, Deputy Chairman, Planning Commission and Chairman, RIS, releasing the *Asian Biotechnology and Development Review.* On his right are Dr V R Panchamukhi, Director General, RIS and Dr. Mark Cantley, Advisor, Life Science European Commission Research Directorate-General, Brussels.

Dr. W.G. Padolina, Deputy Director-General, International Rice Research Institute, Manila, delivering the keynote address at the conference.

Launching of the *Asian Biotechnology and Development Review* at the International Conference on Biotechnology and Development: Challenges and Opportunities for Asian Region, New Delhi, 26-27 February, 2002



From Left: Shri K.C. Pant, Deputy Chairman, Planning Commission and Chairman, RIS; Dr. V. R. Panchamukhi, Director-General, RIS; Dr. W.G. Padolina, Deputy Director-General, International Rice Research Institute, Manila; Dr. Manju Sharma, Secretary, Department of Biotechnology; and Dr. Nagesh Kumar, Deputy Director-General, RIS.

INTERNATIONAL CONFERENCE ON
BIOTECHNOLOGY AND DEVELOPMENT:
CHALLENGES AND OPPORTUNITIES FOR ASIAN REGION
February 26 & 27, 2002, New Delhi (INDIA)
Organised by:
Dept. of Biotechnology
Govt. of India
UNESCO
PARIS
Research and Information System
New Delhi
Dr. M. S. ALAM
Dr. S. CHATURVEDI
Dr. SANDH

From left: Dr. T.V. Ramanaiah, Scientist, Department of Biotechnology, New Delhi; Dr. Reynaldo E. de la Cruz, Professor of Forest Biology, National Institute of Molecular Biology and Biotechnology, University of the Philippines Los Banos College, Laguna, Philippines; Dr. M.S. Alam, Representative of UNESCO, New Delhi; Dr. Sachin Chaturvedi, Research Associate and Managing Editor, *ABDR*, RIS; and Dr.Sandhya Tiwari, Deputy Director, Confederation of Indian Industry, New Delhi.

Biotechnology, Innovation and Development*

William G. Padolina**

In this day and age, it is the common desire of all nations to be strong, prosperous and secure. The advent of new challenges related to competition within a liberalized trade environment has given rise to new stresses in national life. Recognizing the fact that "technological backwardness is not usually a mere accident" (Abramovitz, 1986), it is imperative that the developing countries formulate strategies to achieve an adequate level of scientific and technological competence especially in the emerging technologies. Setting up a functional system of innovation in a country is going to be a major determinant to their competitiveness in the agriculture, industry and the service sectors.

One of these emerging technologies is biotechnology. One would have to ponder how biotechnology, innovation and development interrelate with the caveat that biotechnology is simply one of the many technologies that need to be harnessed by any national system of innovation and mainstreamed into the development agenda. One is fully aware that biotechnology covers many techniques and it may not be useful to group them together in this discussion. However, these techniques are interrelated and they have a cumulative impact. But recombinant DNA technology is the hallmark of modern biotechnology. Therefore, we will make references to both at appropriate places.

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* Based on the keynote address delivered at the International Conference on Biotechnology and Development: Challenges and Opportunities for Asian Region, New Delhi, 26-27 Feb 2002.

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The Continuing Challenge

The development agenda now requires economically resilient, prosperous rural communities which are at the same time able to manage competitive industries and practise integrated and sustainable practices especially with regard to land, air and water resources. Many people live better lives now, but still many people have been left out. With all the wealth in the world, we still have 1.2 billion people living in extreme poverty, unable to gain access to even the minimum basic needs of food, housing, education, health care, potable water, and livelihood. In addition, the science and technology capabilities of developing countries are far too limited to deal adequately with the enormous problems of development. Only 4 per cent of the world expenditure on R&D and about 14 per cent of the world's supply of scientists and engineers are in developing countries, where more than 80 per cent of the world's people live.

Let us take the case of agriculture. Today, agriculture deals increasingly with many tradeable items that must compete and contend with the vagaries of the global market. While many still hold the traditional view that agriculture is a low-technology activity and that agriculture cannot and need not be competitive, it is becoming increasingly clear that agriculture is a knowledge intensive activity and must be managed as such if it were to be competitive. This defeatist attitude has caused many farming operations to be inefficient, with the farmer feeling helpless and losing control of his operations. Government, on the other hand, fearful of social unrest, persists in providing short-term rescue measures that perpetuates the vicious cycle of inefficiency.

In the case of the environment, the effective management of the relationship between sustainability and productivity is crucial if one wants to maintain adequate levels of productivity while preserving the integrity of environment. There one needs to understand the regenerative capacity of natural ecosystems and the earth's capacity to absorb waste. Recent developments show that the powerful tools of modern science, including biotechnology and information technology, could provide vital information to serve the purposes of defining sustainable productivity, especially at the farm level.

Be that as it may, one finds that too little of the great power of modern science and technology has been directed at development. These discussions are being held at a time when the world demands new, creative and fast solutions to the chronic ills of poverty and the difficulties encountered in development. It is clear that there are no silver bullets that will untangle the complexity of poverty and environmental degradation. But here one is facing a treasure trove of new knowledge, so vast and waiting to be applied to these problems of mankind. There is no doubt that poverty elimination in this knowledge-intensive age will require knowledge-intensive strategies. Unfortunately, these discussions and debates in the modification of genes, especially in crops, are so intense, widespread, complicated, often emotional and frequently inconclusive. They have often run around in circles and lost precious time. Given the vast amount of knowledge now available in the field of gene technology, and the rapid pace at which new knowledge is being discovered, it is a shame that very little of this new knowledge has found its way to the solutions to combat poverty, hunger and want.

Biotechnology in the Context of Poverty Alleviation

There are now research tools available that may overcome many of the technical roadblocks that limit the application of conventional biological techniques in agricultural research especially in the area of varietal improvement (Persley and Lantin, 2000; Pinstrup-Andersen and Schioler, 2000; Commission of the European Communities, 2001). Since the discovery of recombinant DNA technology by Cohen and Boyer in 1973 and many other advances in molecular biology, researchers have used and improved on these techniques. The great strides achieved in the biological research attest to the precision and rapidity of these techniques.

The goal of any research activity in agricultural biotechnology is a product or a process robust enough so that farmers can use them. Notwithstanding the sophisticated laboratories and the high level of training required of researchers, the end products are similar to those generated by conventional means such as a seeds, planting materials, diagnostic kits or processes. These products forms hide the tremendous amount of investment and testing to get to the point of application in the farmers' fields (Charles, 2001).

Sustainable Development

Agriculture is an activity that does come at a cost to the environment (Benbrook, 2002). In a recent forum, Peter Raven (2002) observed that any form of agriculture is "extremely damaging to biodiversity." In fact, Tilman et al. (2001) predict that agriculture will be a major driver of global environmental change in the next 50 years. Minimizing harm to the environment will depend on man's ability to anticipate and prepare for the consequences of his activity. This is possible only if the best available information is accessible so that planning and decision-making may be guided by reliable forecasts (Clark et al. 2001). Precise and timely information derived from new tools of gene technology will allow the generation of high-quality information needed to monitor agricultural activities to provide an on-line, real-time early warning system to obviate negative effects on the environment. A detailed study of gene by environment interaction can provide the scientific basis for sustainable development. Robert Solow(1992), the 1987 Nobel laureate in economics, believes that it is the well-being of future generations that will make the concept of sustainability reasonable and useful. Solow maintains that "technological knowledge" is a contributory component towards sustainability.

Recent Progress in Biotechnology

Tools that allow to improve life forms and demonstrate how they behave or react to the environment are now available. Genetic material can be moved across unrelated species. The genome of organisms can be decoded, mapped, and related to phenotype. This new knowledge can then be applied to understand the interaction of crops and their environment. The availability of precise tools that significantly reduce uncertainties in the experiment, accelerate the pace at which new data is generated and reduces the time to get to a useful product.

The tremendous power unleashed by the new tools in molecular biology to rapidly decipher the genetic code of organisms, including that of the human being, is expected to provide information whose depth and breadth is still to be understood. The use of high throughput systems such as DNA chips, combined with the application of robotics and computers to chemometrically process large numbers of samples, has caused the very rapid generation of information. The methods for the rapid analysis of proteins and other biological molecules use the latest chemometric techniques like pyrolysis mass spectrometry, fourier transform infrared spectrophotometry, liquid chromatography-electrospray, and many others. Bioinformatics has improved the speed of data collection aided by high powered computers matched by specially designed software.

As a consequence of the emergence of these powerful techniques, new fields of science have emerged such as genomics, transcriptomics, proteomics, metabolomics and structural biology. These new sciences have revolutionized not only the breeding of improved crops and animals, but have also provided quality information on how the plant behaves within an ecosystem. For example, the integrative and comprehensive nature of genomics and related sub-disciplines provide information that will make it possible to understand the behaviour of organisms and thus enable greater control of their action. Techniques to characterize, manipulate, and model the entire reaction systems and metabolic pathways will yield useful information on specific products and specific behaviour related to certain environmental practices. These pieces of information are of crucial importance as tools for the improvement of productivity in a manner that does minimal harm to the environment.

Moreover, bioremediation, known as the use of biological agents, usually micro-organisms to treat agricultural and industrial wastes, is fast gaining ground. Micro-organisms respond to environmental stimuli and their responses are controlled by their genes. Thus, a better understanding of the interaction between genes and the environment can lead us to more environment-friendly cultural management schemes in crop and animal production.

The Challenge – Rough Road Ahead

Even as we gather momentum to apply this productivity enhancing innovation, one faces many hurdles that need to be overcome. There is a perception that the world already produces enough food for all and that food insecurity is not a result of global shortage of supply but is there owing to the problems of distribution and marketing. On the basis of this observation many argue that one needs no productivity enhancing technologies.

New products and new life forms, created by the application of the tools of modern biotechnology, are perceived to have yet unknown effects on the environment and human health. Although genetically modified organisms (GMOs) are now subject to very rigid biosafety tests and scrutiny, before they are released to the environment, there is still a lurking fear that they may still cause some harm which is yet to be discovered. The high cost of research in modern biotechnology has caused the application of intellectual property rights protection on most of the discoveries, thus, limiting access to vital scientific information. New technologies and products generated are protected and can be released only under certain conditions. Thus, resource-poor farmers have difficulty in gaining access to improved varieties of various crops, some of which are transgenic which have been released for commercial applications. To respond to this gap, institutions that have been set up to produce public goods, such as the international agricultural research centers and publicly funded national research institutions, could attend to the research needs and provide new technologies to resource-poor farmers.

Capacity Building for Innovation

National programmes aimed at poverty elimination need, among others, highly trained people who can help assess the potentials of new processes and technologies. Each country must have internal capacity, a national system of innovation, to identify and absorb emerging technologies that they consider most useful for their development programmes. In striving towards a sustainable strategy for development, we must face the reality that in poor countries, where one is struggling to keep body and soul together, it is not common to expect that its citizens will come up with an innovative idea and have the energy to pursue it. For developing countries, it is, therefore, under severe constraints that sustainable development strategies have to be designed.

Concluding Remarks

In this era of expanding knowledge, and faced with the challenges to apply new tools towards the elimination of poverty, a strong partnership among all sectors involved in research and development is needed. To ensure the effective delivery of new technologies to the resource-poor farmers, international agricultural research organizations and other research institutions, public or private, must now work together and explore new modes of institutional governance. These institutional arrangements should be transparent, flexible, mutually beneficial and efficient.

However, as rapidly as new knowledge is generated by these new tools, so is the conduct of science made more complex by transactions on intellectual property rights and other regulatory protocols. Hopefully, as more detailed knowledge on the genome is made public, research will proceed without delay so that the fruits of modern science and technology will be shared by all mankind in a timely way. Poverty elimination could only be possible if we can unleash the innovative capacity of the poor people. Unlocking this energy to create new wealth requires governance, social engineering, and new rules of trade and technology exchange.

Thus, it is submitted that all discussions in biotechnology, specifically gene technology, should be reckoned within the context of a new wave of tools which form the arsenal of innovation. We must strive towards a total approach, harnessing this innovative capacity towards a better life for all.

As we engage in debates and discussions, it may be useful to just look back into the mid-1970s when a group of molecular biologists, sponsored by the US National Academy of Sciences, called for a temporary moratorium on certain experiments that involved the genetic manipulation of living cells and viruses. The group was concerned that these genetically modified organisms would be health hazards and it called for a voluntary moratorium, an unprecedented act by scientists. However, in view of the disagreement among other scientists that there would indeed be health hazards, an international meeting was organized on 24-26 February 1975 at the Asilomar Conference Center on California's Monterrey peninsula "to review scientific progress in research on recombinant DNA molecules and to discuss potential hazards of this work." Prominent in the agenda was the issue on whether the moratorium in certain aspects of research should be lifted and how experiments could continue with minimal risks to workers, to the public and to the environment. (Berg et al., 1975)

The participants at the conference agreed that recombinant DNA research should proceed but under strict guidelines (Berg et al. 1975). However, they also recognized that "future research and experience may show that many of the potential biohazards are less serious and/or less probable than we now suspect." Two years after the Asilomar Conference, Cohen (1977), one of the signatories in the call for a moratorium in 1975 observed that: "What began as an act of responsibility by scientists, including a number of those involved in the development of the new techniques, has become the breeding ground for a horde of publicists—mostly poorly informed, some well-meaning, some self-serving....Unfortunately, much of the speculation has been interpreted as fact." Furthermore, Cohen (1977) states "whether we can afford to allow preoccupation with and conjecture about hazards that are not known to exist, to limit our ability to deal with hazards that do exist." He urges us to "examine the 'benefit' side of the picture and weigh the already realized benefits and the reasonable expectation of additional benefits, against the vague fear of the unknown that has in my opinion been the focal point of this controversy." In a review, 20 years after the Asilomar Conference, Berg and Singer(1995) concluded that "no documented hazard to public health has been attributable to the applications of recombinant DNA technology." Furthermore, they noted that "the most profound consequence of the recombinant DNA technology has been our increased knowledge of fundamental life processes." Berg was the chair of the group that called for the moratorium in 1975.

Although everyone admits that all technologies and activities involve some degree of risk, the current debates about levels of risk in biotechnology, especially gene technology, will undoubtedly continue especially on the point of the acceptability of different levels of risk. However, decisions have to be made sooner on which of these menu of tools will be used and the acceptability of risks associated with such tools.

Science is necessary but not a sufficient basis for making these difficult decisions. The issues cannot be handled by scientists alone. We are presented with a complex set of considerations, influenced by our perceptions of risk as mankind increasingly moves into a lifestyle that wants to minimize risks. But we must remember that an enlightened decision is only possible if there is quality information. This is where science plays a vital role, for it provides the rigour and objectivity that is often not observed in political decisions.

The emergence of new sources of strain and tension poses a challenge to the prevailing system of innovation. We are faced with lingering poverty and suffering, new international conventions and agreements, impact of globalization and our desire to insure sustainability. Whatever difficulties we experience are symptoms of the inadequacy of our approaches and solutions. One is afraid of the fact that biotechnology may become a focal point of a lot of tensions and in many instances biotechnology may be exploited to serve some other hidden agenda. But, based on the attention it has been receiving, there is no doubt that modern biotechnology is even today a major force, influencing innovation and change globally. It is for this reason that we must now arrest this looming impasse. It is time to ask ourselves whether we will continue to be influenced by a reasonable analysis or increasing fear. While there is very little debate on the use of genetically modified organisms (GMOs) for pharmaceutical purposes, there is a disagreement on the use of GMOs for food. We must realize that the prolonged discussions and debate are not without cost.

The transfer of technologies has been delayed, transaction costs are high and the entry barriers to gain access to modern biotechnology have been increasing each day. Also, there is the threat of the stifling of discovery and new knowledge. But the most serious effect that, it is hoped, will not flourish, is the mounting distrust amongst ourselves. Unfortunately, in many cases the integrity of information is not upheld and there is a selective perception. This mounting distrust is intensified and aggravated by the use of electronic media to rapidly convey all kinds of information and misinformation to a very wide audience. This weakens the fabric of cooperation and understanding and engenders suspicion and confrontational politics. This adversarial stance does not help us any way. Many times these activities can be willfully destructive, a kind of "low grade terrorism." This growing intolerance is an indication that we can no longer engage in reasoned debate and that science is no longer secure because of laboratories set to fire and experiments physically destroyed. These are not healthy developments and we must strive to build trust so that we can engage in reasoned dialogue. Fortunately, there are still those courageous souls who continue to uphold reasoned discussion sans intolerance and bigotry. In their book *Seeds of Contention*, Pinstrup-Andersen and Schioler (2000) focused on the potential benefits and costs of GM crops for developing countries. They argue that increased agricultural productivity is not only going to be enough in addressing hunger, but there is also need of those crops which are disease-resistant and are able to withstand other environmental stresses.

In a recent public forum, Peter Raven (2002), head of the prestigious Missouri Botanical Garden, observed that there are "thousands of papers and analyses" that have been done on the subject of safety to human health and the environment. But the problem is that some sectors prefer to ignore these information and then claim that nothing has been done. Prof. Sir Colin Berry (2001) observes that public discussions of risks, such as the one that is currently taking place regarding safety of GMOs, "consistently overestimates dangers and undervalues the benefits." He further avers that "information is probably the answer, but it must be provided in a way that allows the requirements of society to be reflected in the content." Prof. Sir Colin Berry (2001) further suggests: "We must seek agreement about the desirable outcome we wish to achieve – which environment we protect, what birds must be favoured, how long we should live. In all of these instances, some will hold opposing views."

Discussion and debate, based on uncritical belief, do not speak well of citizens who expect to thrive in a knowledge-based world. History tells us that the damage inflicted by prejudice and bigotry is very difficult to repair. Thus, physical violence in the form of destruction of experiments and burning of laboratories and offices must be stopped. Legislation from all over the world to criminalize field-testing of GMOs is a very counterproductive move.

Finally, let's join others in raising the issue of accountability. This applies to all parties in the debate. We need to accept responsibility for the consequences of the positions we espouse. What difference are we making in the lives of these poor farmers as we engage in these debates? If we believe that technology can add value to our development agenda and deepen capital investments, why can we not work together in good faith to assess, with all the rigour that we can bring to bear, the vast amount of new information that is generated everyday. In good faith, let us have reasoned and informed public discussion knowing fully well that our understanding of genetics has deepened, thus challenging our traditional ideas and values.

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Biotechnology in Europe – 20 Years' Experience and Current Strategy[*]

Mark Cantley[**]

Background

Modern biotechnology originated in research laboratories in the developed world some 30 years ago, building on deeper foundations. The 20th century opened with the re-discovery of Gregor Mendel's papers on genetics and closed with the sequencing of the human genome. We are dazzled by the dramatic progress. The new techniques and instruments and discoveries should not lose sight of the fact that the main new ingredient is 'knowledge'. Knowledge is not inherently toxic, but its applications can be frightening. The very phrase, "the life sciences" may be considered aggressive, as an assertion of the invasion by science into the long-familiar mysteries of birth and life, sickness and disease, reproduction and death. Mysteries surrounded by taboos, sacraments, cultural restrictions and inhibitions – "tread lightly, because you tread on my dreams".

Knowledge is tricky stuff for scientists or engineers, economists or politicians. It is pervasive, disruptive of established patterns and institutions, irreversible and globally available to customers and competitors in every continent. It is subversive of established products, market shares and ideas but it is fundamental to innovation, to improvement, and to addressing the age-old problems of food supply and health. It is no less fundamental to the necessary transition towards a more sustainable pattern of economic activity, as we struggle to improve the state of human nutrition for a population increasing from 6 to 9 billion in our children's lifetimes, using no more than the currently cultivated area, and attempting to delay and reverse the degradation of the natural environment.

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[*] Paper presented at "International Conference on Biotechnology and Development: Challenges and Opportunities for Asian Region" held on February 26-27, 2002 in New Delhi.

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The Expanding Challenge to Public Policy

Modern biotechnology started in the research laboratories, and insofar as it came to the attention of policy-makers, usually with demands for money, it was the business of the Research Minister. Early concerns were expressed about the power of the new techniques in the mid-1970s, and for a few years there was noisy debate and controversy about whether the new knowledge and techniques would unleash new threats. The subject was a gift to cartoonists. Precautionary regulations and guidelines were implemented, then gradually relaxed, as research and growing experience diminished the initial concerns. By 1986, the leaders of the developed countries meeting in the OECD Council could state, on the basis of expert consensus, "*there is no scientific basis for specific legislation to regulate the use of recombinant DNA organisms*".

That statement remained the basis of US policy – they could handle the regulation of vaccines, drugs, foods, seeds, etc. under the statutes and agencies already set up for those different sectors, and the relevant agencies could handle the new technology with minor adaptation of existing procedures. In Europe, this proved more contentious. Was technology-specific regulation necessary, or could sectoral procedures be adapted to cope? For pharmaceuticals that has remained the policy. Scientific opinion in general favoured this line – to throw vaccines, foods, seeds, industrial enzymes all into one regulatory bag did not make sense, and there was already relevant legislation. But in the late 1980s, the European Union was creating a common market, seeking to replace divergent national rules by harmonised community-wide regulatory frameworks – and already some countries were implementing technology-specific legislation on the products of biotechnology. The result, in 1990, was community-wide legislation, on the contained use of genetically modified micro-organisms and on the field release of genetically modified organisms.

As this debate developed in Europe and elsewhere in the world, one would realise that the research ministers had been pushed aside. The fermentation pharmaceutical industry was by now producing new vaccines, and high value pharmaceuticals – growth hormones, animal and human; insulin for diabetics; and a growing range of interferons. The industry and health ministers were involved. The application of modern biotechnology to cultivated crops and farm animals engaged the interest of the Minister of Agriculture: was this a competitive threat, or a necessary element of progress? The release in open field of genetically modified seeds and plants, and the vaccination of animals raised questions also for the Minister of the Environment. And if different rules were adopted in different parts of the world, evidently the problems would reach the in-trays of the Ministers of Trade. Questions of patentability were being fought in the patent offices and in the legislatures: a 1982 OECD survey warned the Europeans that their patent protection in biotechnology was incoherent and disadvantageous. It took them 16 years of often bitter argument to adopt a directive intended to harmonise and improve the situation.[1] Several Member States are still refusing to transpose that fully into national legislation.

In every national capital, the same inter-agency or inter-ministerial tensions arose. In countries blessed or afflicted with division of powers between national and provincial governments, the debates were still more complex. At global level, every agency of the United Nations became involved in some facets of the debate on biotechnology. These arguments are continuing today in both developed and developing countries. In Europe, we have been facing a *de facto* moratorium since 1998 because in several countries the Environment Ministers refuse to authorise further release of products of modern biotechnology, at least until additional legislation on traceability and labelling has been adopted. At global level, biotechnology-related arguments are in progress in the Codex Alimentarius Commission, World Trade Organization, Convention on Biological Diversity, and its offshoot, the Cartagena Protocol on BioSafety.

The European Situation and Global Context

In Europe, the situation is for the moment deadlocked and science and industry are complaining about the burden and constraint of unnecessary and overweight regulation. Seed companies have taken their research out of Europe. Notifications of field trials in the European Union – authorised at national level – collapsed from 256 in 1997, to 44 last year. The proponents of modern biotechnology in Europe are frustrated, but are confronted by a five-legged animal of apparently great political power; the five "legs" being:

- the Ministries of the Environment, which have gained much increased power, authority and prominence in these debates;
- public opinion, at least as reported by surveys and media (although the correlation between survey results and human behaviour is uncertain, since the first genetically modified food products – canned tomato purée - were commercially successful);
- the media, which on the whole have reflected popular suspicions of scientific expertise, fuelled by some high profile apparent "failures", and a campaigning spirit hostile to the high priests of science, government, or other supposed "authority";
- the "NGOs", non-governmental organisations, supposedly campaigning for environmental protection, consumer interests or other worthy causes, and whose visibility, membership and revenues depend

upon continual prominence on the front pages of popular journals and television;

- the pesticide industry, which has been unhappy to suffer major reductions in sales as a result of the adoption and success of genetically modified pest resistant plants, dramatically reducing the need for pesticide spraying on crops such as pest-resistant cotton and corn.

Faced with this fierce transgenic monster, governments and companies are "running scared", most evidently in the speeches of Ministers ("we need more research, we must apply the precautionary principle"), and the unfortunate retailers, who find themselves in the frontline of boycott, demonstration and physical attack. Even retailers who were involved in the (very successful) launch of the first genetically modified food product in Europe – the Zeneca tomato purée - now boast to their customers of having removed genetically modified foods from their stores. No less exposed are the farmers bold enough to volunteer to conduct field trials of transgenic crops – for although such research may be addressing questions of environmental safety and public interest, there is a greater short-term interest in the publicity which protesters can win by attacking such trials. The downside risks for the protesters are diminished by the reluctance of juries to convict the offenders.

The European Commission, thus, finds itself in the proverbial phrase, between a rock and a hard place. The Treaty providing legal basis for EU legislation, international agreements such as the those of the World Trade Organization and indeed the fundamental responsibility to the public interest, all oblige the Commission to have regard to the scientific assessment of safety and environmental protection. It is increasingly evident from the EC-sponsored research, from the results of research conducted around the world, and from the growing cumulative experience of cultivating transgenic crops and consuming the products, that broad assertions of inherent risk in the technology are false. Indeed, it is becoming clear that the intensive regulatory scrutiny, and the precision of the techniques, are ensuring that the few products which have been allowed onto the markets, are indeed delivering the promised benefits; the reduction in pesticide use on transgenic cotton would be one of the most obvious.

The Commission is constrained by the political procedures of the legislative processes of the European Union. It cannot in Brussels resolve problems of inter-ministerial coordination in 15 Member country capitals, nor ignore the political pressures and demands expressed through the directly elected European Parliament. Nonetheless, the Commission is well aware of the challenges and opportunities offered by modern biotechnology. Over the past year, President Romano Prodi has taken the lead in catalysing a renewed inter-service effort to develop a "strategic vision" for the life sciences and biotechnology.

A major public consultation was launched in September 2001, with a high profile conference, and an invitation to all interested parties to contribute to a public, on-the-web discussion. The result has been an intense period of inter-service argument and negotiation within the Commission, culminating in the production (January 2002) of the report, *'Life Sciences and Biotechnology: A Strategy for Europe'*, containing a 30-point Action Plan. That report has been favourably received a few days ago by the Industry and the Research Ministers of our Member countries, meeting in Gerona, Spain, and it will be on the agenda of the European Council, the Prime Ministers and Presidents, meeting in Barcelona next month.[2] Also on the agenda of the Barcelona summit will be a re-examination of progress on the bold strategic goal for the next decade which Europe's leaders set out two years ago at the Lisbon Summit in March 2000:

Back to our starting point: not just knowledge, but a knowledge-based economy and sustainability. In rich world or poor, there is no escaping the imperatives of food, health, and the protection of the environment.

Modern biotechnology is central to the transition towards a knowledge-based economy. It is no less central to the challenge of managing the transition to a more sustainable economic system, a more sustainable agriculture, in spite of the pressures we shall face over the next few decades from the inescapable increase in our numbers. The pressure of numbers merely underlines and amplifies the need to apply our new knowledge, and to welcome, not block, the technologies which will enable us to meet these challenges.

If one contextulises European position in a global framework, one finds that Europe is the world's greatest trading block, number one importer of agricultural products and number two to the US in agricultural exports. European product rules have an impact far beyond their shores, for better or for worse, and one must appreciate the fundamental role played by common scientific understanding in providing a basis for international agreements, be it on trade, on research, or on intellectual property. In scientific activities, Europeans have long been internationalists. In the Programme Committees which oversee programmes such as that on "Quality of Life and Management of Living Resources", Europe has 31 countries represented around the table. It is just 28 years since the founding of the Community's science and technology policy, but we have over that period seen dramatic increase in the scale of our research programmes, and particularly those in the life sciences. They have grown from a first five-year programme of Biomolecular Engineering of 15 million in 1982-86, to the current 2.4 billion Quality of Life programme, 1999-2002. We have also formalised our scientific and technical cooperation with a growing number of countries around the world. Most recently, we signed with India an Agreement on Co-operation in Science and Technology.

It is clear now that the central and increasing role, which modern biotechnology must play in many sectors and public policy, must provide a supportive framework for innovation, investment and trade.

Suggested Readings

Life Sciences and Biotechnology: A Strategy for Europe. January 2002: a comprehensive, strategic restatement of the Commission's strategic vision for the life sciences and biotechnology.

EC-sponsored Research on Safety of Genetically Modified Organisms: A Review of Results, October 2001: an overview of the results of some fifteen years of research, 81 projects, cost 70 million, involving over 400 teams.

European Commission: http://europa.eu.int/comm/research/index_en.html leads into information about the research policy of the European Union, and the EC-sponsored research programmes. Details of projects within the current "Quality of Life" programme (2.4 billion, 1999-2002) are available at http://dbs.cordis.lu/fep/LIFE/LIFE_PROJ1_search.html. For the 246-page report on the past 15 years of EC-sponsored research on the safety of genetically modified organisms, see <http://europa.eu.int/comm/research/quality-of-life/gmo/index.html>. For our new *Strategic Vision* report, January 2002, see http://europa.eu.int/comm/biotechnology/pdf/policypaper_en.pdf.

Research: The Cordis (Community R&D Information Service) at http://www.cordis.lu/en/home.html gives a wealth of information regarding programmes, projects, calls for proposals, databases, webservices, etc.

Biotechnology for schools: The European Initiative for Biotechnology Education provides teaching materials and ideas developed by a Europe-wide team – see <http://www.rdg.ac.uk/EIBE/ENGLISH/INTRO.HTM>. UK contacts include Dr. John Grainger at NCBE, National Centre for Biotechnology Education, The University of Reading: see <http://www.ncbe.reading.ac.uk/NCBE/GMFOOD/>.

General public information: A wealth of choice. Excellent information briefs are available from the European Federation of Biotechnology's Task

Group on Public Perceptions of Biotechnology, website at <http://www.kluyver.stm.tudelft.nl/efb/TGPPB/Home.htm>, or by post from Dr David Bennett, Secretary, Secretariat, EFB Task Group PPB, Oude Delft 60, NL-2611 CD Delft, The Netherlands. Phone: +31 15 212 7800; Fax: +31 15 212 7111. efb.cbc@stm.tudelft.nl

CropGen: A consumer and media information initiative, CropGen's mission is to make the case for GM crops by helping to achieve a greater measure of realism and better balance in the UK public debate about crop biotechnology. Site: <http://www.cropgen.org/databases/cropgen.nsf/?Open>. They recently produced a useful recent report on the safety of GM food: *One Hundred Percent Safe?* available at <http://www.checkbiotech.org/pdf/cropgenfullreport.pdf> or on request to: information line 0845 602 1793 (local rate) during normal office hours.

Government: See UK DTI site at http://www.dti.gov.uk/bioguide/dti.htm, and links from there.

Industry: See the site of EuropaBio, the European Association for BioIndustries, at <http://www.europabio.org/pages/about_us.asp>; the (UK) BioIndustry Association site at http://www.bioindustry.org/; the US-based Biotechnology Industry Organization's site at <http://www.bio.org>. All offer many other links.

Other sources: Innumerable. Information on biotechnology and genetically modified crops and foods is offered, with or without bias, by many companies, such as Syngenta (http://www.syngenta.com/en/customer/biotech.asp) or Monsanto (<http://www.biotechknowledge.monsanto.com>), environmental groups, such as Greenpeace (<http://www.greenpeace.org/~geneng/reports/food/intrfood.htm>) or Friends of the Earth (<http://www.foeeurope.org/biotechnology/about.htm>), consumer groups, such as Consumers' Association (<http://www.which.net/campaigns/gmfood/gmcontents.html>). Most good sites also offer a wealth of links to other sites.

Endnotes

1 Directive 98/44 on the Protection of Biotechnological Inventions was adopted on 6 July 1998, almost 10 years after the first proposal for such legislation was put forward by the Commission, in October 1988. It should have been transposed into national law in the 15 Member countries of the European Union by 30 July 2000.

2 Postscript: the Conclusions of the Barcelona meeting stated: "Frontier technologies are a key factor for future growth. The European Council asks the Council to examine before June 2002 the Commission's communication *"Life Sciences and Biotechnology – a strategy for Europe"*. It asks the Council and the Commission to develop measures and a timetable which enable Community businesses to exploit the potential of biotechnology while taking due account of the precautionary principle and meeting ethical and social concerns. The Commission is invited to report on progress in advance of the Spring European Council 2003."

Status of Agribiotechnology in the Philippines[*]

Reynaldo E. de la Cruz[**]

Introduction

The Philippines has a land area of 30 million hectares and a population of more than 70 million. In 1997, the combined area devoted to agriculture was 10.3 million hectares. Rice and corn have a combined area of 4.75 million, followed by coconut (4 million), sugarcane (0.70 million), banana (0.21 million), pineapple (0.04 million) and other crops (0.60 million). In terms of productivity, rice and corn have a combined annual production of 26.9 million metric tonnes (mmt), banana (21.6 mmt), coconut (12 mmt), sugarcane (3.4 mmt), pineapple (1.6 mmt), coffee (0.1 mmt) and other crops (2.4 mmt).

The country is a major producer of coconut, sugarcane, banana and pineapple but is not self-sufficient in rice and corn. These commodities have to be imported. Most of the soyabeans, required for food and feeds, have to be imported from the US.

Despite the thrusts to be an industrialized country, the Philippines remain an agricultural country. More than 70 per cent of the population is directly or indirectly dependent on agriculture. Small farmers own most of the land. The high population rate of 2.8 per cent annually has placed tremendous pressure on agricultural lands. Prime agricultural lands are now being converted into resettlement areas and for industrial uses. To make room for more agricultural lands, huge areas of the natural forest had been cleared. This had caused tremendous disturbance of the ecosystem, erosion, disruption of the water cycle, and flooding during the rainy season. As a consequence, agricultural productivity had declined during the years.

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[*] Revised version of the paper presented during the "International Conference on Biotechnology and Development: Challenges and Opportunities for Asian Region" in New Delhi, February 26-27, 2002.

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Biotechnology in the Philippines

The Philippines started its biotechnology programmes in 1979 with formal creation of the National Institute of Molecular Biology and Biotechnology (BIOTECH) at the University of the Philippines Los Banos (UPLB). In 1995, three other biotechnology institutes were established within the University of the Philippines (UP) system. One was established in UP Diliman to focus on industrial biotechnology, another in UP Manila to focus on human health biotechnology, and in UP Visayas to focus on marine biotechnology.

The biotechnology institute in UPLB continues to provide leadership in agriculture, forestry, industrial, and environmental biotechnology. Other research institutes at UPLB doing biotechnology research are Institute of Plant Breeding, Institute of Biological Sciences, Institute of Animal Sciences, Institute of Food Science and Technology, National Crop Protection Center, College of Veterinary Medicine, and the College of Forestry. The National Institute of Molecular Biology and Biotechnology based in UP Diliman and the Institute of Biological Sciences in UPLB offer graduate programmes in molecular biology and biotechnology.

Outside UPLB, research institutions actively involved in biotechnology research are Philippine Rice Research Institute (PhilRice), Cotton Research and Development Institute, Bureau of Plant Industry, Bureau of Animal Industry, Industrial Technology and Development Institute, Fiber Industry

Development Authority, Philippine Sugar Research Institute, Philippine Carabao Center, and Philippine Coconut Authority.

Status of R&D Programmes in Biotechnology

The types of research undertaken in the Philippines from 1980 to 1999 are mainly conventional biotechnology. The results of a survey on the budget spent for biotechnology R&D from 1989 to 1999 are shown in Table 1.

Out of 266 projects funded by government, 20.5 per cent was for biocontrol, 19.5 per cent for tissue culture, 16.5 per cent for biofertilizers and soil amendments, 16.3 per cent for food and beverage, 7.5 per cent for feed component, 6 per cent for enzymes, 2.6 per cent for diagnostics, 1.5 per cent for farm waste utilization, 1.1 per cent each for vaccines and animal reproduction, 4.6 for molecular markers and 2.7 per cent for GMOs.

Table 1. Type of Biotechnology R&D, Number of Projects, and Percentage of Total Projects Funded from 1980 to 1999

Type of Biotechnology R&D	Number of Projects	Per cent of Total
Biocontrol	55	20.5
Tissue Culture	52	19.5
Biofertilizers and Soil amendments	44	16.5
Food/beverage	43	16.3
Feed component	20	7.5
Enzymes	16	6.0
Diagnostics	7	2.6
Farm waste utilization	4	1.5
Vaccines	3	1.1
Animal reproduction	3	1.1
Molecular markers	12	4.6
GMOs	7	2.7
Total	266	100.0

The Institute of Plant Breeding (IPB) based at UPLB is one of the leading research institution, which has a well-developed biotechnology programme. The IPB Biotechnology Programme involves the following areas:

- Tissue and cell culture technologies – micropropagation and plant regeneration systems; *in vitro* germplasm conservation; disease elimination and distribution of disease-free plantlets; induction of somaclonal variation through mutation and *in vitro* selection.
- DNA marker technologies and molecular farming – markers, genome maps and protocols; varietal fingerprinting, line purity and hybridity testing; molecular characterization of germplasm and diversity analysis; genome mapping and quantitative trait loci analysis and marker-assisted breeding and selection.
- Gene discovery/genomics molecular characterization of genes (ripening genes and insect/disease resistance genes); cDNA library construction for papaya, mango and coconut; DNA sequence analysis; and development;/design of gene constructs.
- Genetic engineering/transgenic technology transgenic crops (PRSV-resistant papaya; BBTV resistant banana and abaca; delayed ripening of papaya and mango; modified fatty acid content of coconut and molecular pharming)
- Plant disease diagnostics – immunological diagnostic kits for plant disease (sugarcane ratoon stunting disease and yellow leaf curl virus in tomato and pepper); PCR-based diagnostics for bacterial wilt of vegetables (*Ralstonia solanacearum*); sheath blight of corn (*Rhizoctonia solani*); ratoon stunting disease (*Leifsonia xyli* subsp. *xyli*) and banana bunchy top virus and papaya ringspot virus.

In 1997, the Philippines passed the Agriculture and Fisheries Modernization Act (AFMA) whose objective is to modernize agriculture in terms of infrastructure, facilities and R&D. AFMA recognized biotechnology as a major strategy to increase agricultural productivity. The law states that AFMA will provide a budget of 4 per cent of the total R&D budget of the agriculture sector for a period of 7 years. According to this, the annual budget for biotechnology should be at most US$20 million.

AFMA operates through the National Research, Development and Extension (RDE) network systems of the Department of Agriculture, which consist of 13 commodities and six disciplines. The 13 commodity networks are rice, corn, root crops, coconut, plantation crops, fiber crops, vegetables/ spices, ornamentals, fruits/nuts, capture fisheries, aquaculture, livestock and poultry and legumes. All 13 commodities include the application aspects of biotechnology in their RDE agenda.

The six discipline-oriented RDE networks are post-harvest and marketing, soil and water resources, agriculture and fisheries engineering, crop protection, social science and policy, and biotechnology. As a discipline, biotechnology focuses on upstream basic research, which includes work in molecular biology, while the commodity networks focus on downstream or applied research.

The main goal of biotechnology R&D under AFMA is to harness the potential of this cutting edge technology to increase productivity of all the commodities in the agriculture and fishery sectors. The Biotechnology RDE envisions to complement the goals defined in the Agriculture and Fisheries Modernization Act (AFMA) through biotechnology. The intermediate goal is the development and application of basic biological information and molecular techniques for the:

- promotion of novel agricultural production and post-harvest technologies,
- improvement of productivity and profitability of farm and fishery commodities, and
- enhancement of sustainable agriculture, forestry, aquaculture and the environment.

The programme seeks to achieve this mission through four sub-programmes, namely:

- Develop and promote the adoption of new production and post-harvest technologies,

- Mitigate harmful impact of farming and fishery practices,
- Manage biodiversity, and
- Help develop sound policies on biotechnology based on scientific research.

It is envisioned that the current budget provided by AFMA will update knowledge base, skills, tools and infrastructure that can be applied to modernize agriculture. Given the numerous applications of biotechnology, scarce resources, limited infrastructure and technical capability in the country, the programme shall seek to optimize return of investments in R&D through the following strategies:

- Immediate access to molecular technologies already developed elsewhere such as genes and gene construct through direct purchase, donation or other IPR instruments,
- Build upon existing strengths in various institutions,
- Integrate efforts, expertise and facilities from and within various institutions,
- Prioritize projects based on the predicted economic returns from the technology,
- Encourage an incentive structure for the science community to innovate and to adopt a multidisciplinary and in-depth approach to the problem,
- Strengthen institutional capabilities especially in terms of human resource and infrastructure support, and
- Involve the private sector in RDE activities.

The National Biotechnology RDE Programme consists of four sub-programmes, namely:

1. Genetic Engineering – the development of transgenic crops and fishes with protection against major pests and water stress, improved nutritional value, higher yields and rapid growth rates; application of molecular markers to facilitate breeding and to manage pests of crops and livestock. On-going projects under this sub-programme are:

- Tobamovirus- and Potyvirus-resistant tomato and squash
- Banana Bract Mosaic Virus-resistant banana

2. Genomics/gene discovery – molecular genome mapping of major crops such as coconut, mango, and abaca, cDNA library construction and application of genomics and bioinformatics in the isolation of genes whose contribution to agriculture and fishery production is quantifiable, e.g. a gene that could increase yields in rice by 70 per cent. On-going project is the coconut genome project which is made up of the following projects:

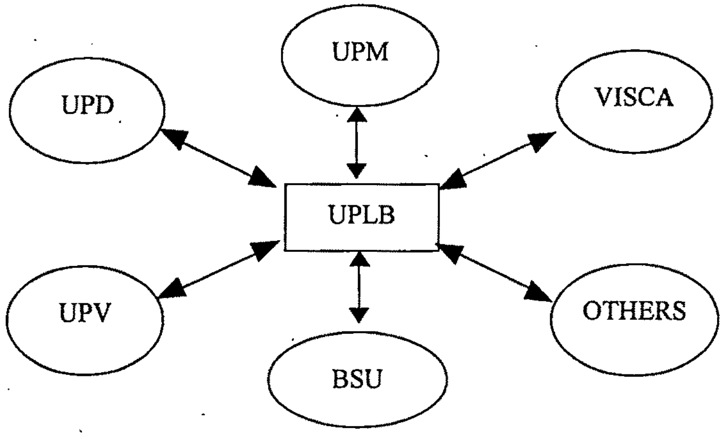
   - Molecular mapping of the coconut genome
   - Coconut genome sequencing project
   - Isolation of tissue-specific, non-crop specific promoters
   - Isolation of growth promoters
   - Isolation of anti-stress genes

3. Diagnostics – the development of biologicals for early detection and control of pests and diseases. Projects should offer alternative solutions to current, high polluting, soil and water degrading technologies. On-going projects are:

   - DNA-based detection of pathogens in aquaculture and vaccine production against hog cholera
   - Field trials of detection kits for plant viruses and vaccines for livestock and poultry
   - PCR-based detection system for *Haemophilus paragallinarium*
   - DNA-based detection procedures for genetically modified plants
   - Molecular diagnostic kits for shrimp hatcheries

4. Socio-economic policy and technology transfer – risk and safety assessment of transgenics, development of standards and quality control measures for biotechnology products, validation of procedures and development of protocols for the detection of biotechnology products. Risk and safety assessment of transgenics shall be

Figure 1. Composition of the National RDE Biotechnology Network

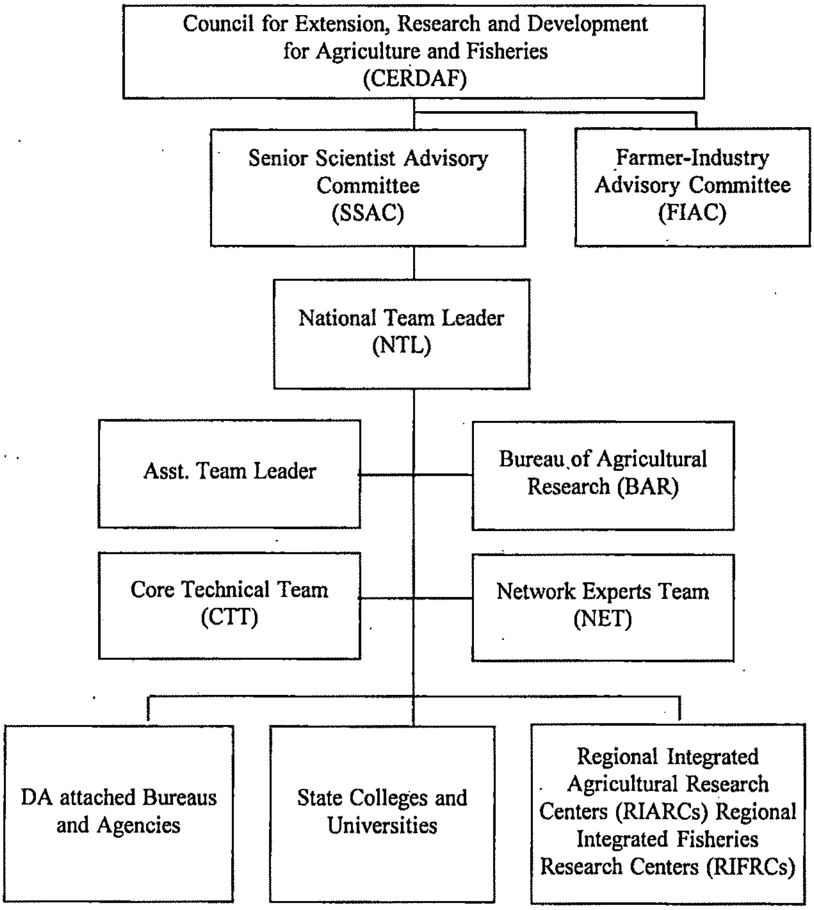


coordinated with projects on the development and testing for the commercialization of transgenics and other biotech products. Projects on the development of quality standards, quality control measures, protocols for the detection of transgenics shall focus on commercial biotech products. On-going projects are:

- Risk assessment of pre-commercial GMOs
- Ex-ante analysis of biotechnology products

To achieve the above goals and mission, the National Biotechnology RDE network was organized, which is made up of the following: the R&D institutions in UPLB, the three National Institutes of Molecular Biology and Biotechnology based in the UP system (UP Diliman, UP Manila and UP Visayas), Benguet State University, Visayas State College of Agriculture, other State Colleges and Universities, and Bureaus under the Department of Agriculture. Funding for the network comes mostly from the Bureau of Agricultural Research under the Department of Agriculture. This network develops the research and development programmes for biotechnology. The institutional network is shown in Figure 1.

Figure 2. Biotechnology RDE Network Organizational Chart


Council for Extension, Research and Development for Agriculture and Fisheries (CERDAF)
Senior Scientist Advisory Committee (SSAC)
Farmer-Industry Advisory Committee (FIAC)
National Team Leader (NTL)
Asst. Team Leader
Bureau of Agricultural Research (BAR)
Core Technical Team (CTT)
Network Experts Team (NET)
DA attached Bureaus and Agencies
State Colleges and Universities
Regional Integrated Agricultural Research Centers (RIARCs) Regional Integrated Fisheries Research Centers (RIFRCs)

In terms of approval of projects developed by the network, all projects go through a review process by three Committees: Senior Scientists Advisory Committee (SSAC), Farmer-Industry Advisory Committee (FIAC), and Council for Extension, Research and Development in Agriculture and Fisheries (CERDAF). The structure of the three Councils with respect to the Biotechnology Network is presented in Figure 2. The FIAC evaluates the proposal in terms of its impact on the problems affecting farmers and industry. This will assure that the proposal is market oriented. The SSAC evaluates the proposal in terms of its technical and scientific merits, competence of proponents, and the support environment (infrastructure, lab facilities). CERDAF reviews the policy aspect of the proposal and approves the budget. The National Team Leader (NTL), who is the concurrent Director of BIOTECH-UPLB, operates the Network. The NTL is assisted by an Assistant Team Leader, four Core Technical Team Members and Network's Expert Team, who serves as resource persons but are usually on call.

Status of Human Resource and Infrastructure

The Philippines does not have the critical human resources required for high-level biotechnology R&D. As of 1999, there were about 250 scientists qualified to do high-level biotechnology R&D. Most of these researchers are affiliated with Universities in the UP System. Others are found in PhilRice, DA Bureaus and DOST Research Institutes.

Laboratory facilities and equipment for upstream biotechnological research exist in some R&D Institutions based in UPLB (Biotech, IPB, IBS, CVM, IFST, and IAS), UPD and UPM. Among the DA Centers, PhilRice is the best equipped laboratory. There is a need, however, to upgrade most of the laboratories in the country.

Biosafety and Risk Assessment

Regulations of R&D in biotechnology are done through a National Committee on Biosafety (NCBP), created by Executive Order 430 in 1990. NCBP is administratively under the Department of Science and Technology but its members come from other line agencies such as the Departments of Agriculture, Health, and Environment. The Committee also consists of eminent scientists in biology, environment, physics, social sciences, and members from the community including NGOs.

NCBP had developed three Biosafety Guidelines for R&D as follows:

- NCBP Series No. 1. Biosafety Guidelines for Small-Scale Laboratory Work
- NCBP Series No. 2. Biosafety Guidelines for Large-Scale Contained Work and Glasshouse Trials
- NCBP Series No. 3. Biosafety Guidelines for Planned Release of Genetically Modified Organisms (GMOs) and Potentially Harmful Exotic Species (PHES).

All R&D proposals for contained or limited field trials of GMOs whether by local or foreign researchers or private sectors are subject to the NCBP guidelines. The country has drafted guidelines for the commercialization of GMO plants. These guidelines had undergone several nationwide consultations with various stakeholders consisting of farmers, fisher folks, NGOs, consumer groups, private sector, and academia. The commercialization guidelines are expected to be signed by the Secretary of DA as a Department Administrative Order of 2002.

Status of Field Trials of GMOs in the Philippines

Two years ago, the NCBP had approved the applications of Monsanto to conduct limited field trials of its Bt corn in two areas in the country. Last year, NCBP had granted Monsanto another permit to conduct limited multi-locational trial for its Bt corn. The results of both the limited field trials and multi-locational trials had shown the effectiveness of Monsanto's Bt corn in reducing infestation of the crop by the Asian corn borer. The average yields of these trials were increased by as much as 40 per cent as compared to non-Bt corn.

While many farmers are happy with the performance of Bt corn, NGOs such as SEARICE, Green Peace and Masipag had been very vocal against the GMO trials in general and the Bt corn trials in particular. There had been many bills filed in Congress and the Senate calling for a moratorium or a ban on the testing. Some of the field trials of Monsanto had been vandalized leading to the destruction of the Bt corn planted in the field.

It is possible that the next field trials of GMOs in the Philippines will be Bt cotton. The private sectors are planning to bring in either Monsanto's Bt cotton or the Bt cotton from China. The Institute of Plant Breeding produced a transgenic papaya resistant to papaya ring spot virus, which may also be tried in the field in 2002 itself or next year.

Status of Importation of GMO Plants, Seeds and Products

The Philippines imports all its soyabean and corn requirements from the US. Since the US do not segregate GM soy and/or corn from non-GM seeds, it is highly possible that these GM seeds had entered the country a long time ago, and had found its way into the human food and animal feeds. Again, there is a big debate in the Senate and Congress as to risk posed by these products to human health, animal health, and the environment. Many of the NGOs had been very vocal in their call for the banning of such seeds and products. Some would like to impose a labelling law for such products. The Philippines, however, had not decided yet to label such GM products.

Three weeks ago, Green Peace had tried to block the unloading of 30,000 metric tonnes of soyabeans by a private company. The demonstrators were able to board the cargo ship, chain themselves on the unloading platform, but left the boat an hour later after getting the media mileage. It is apparent that these activities are purely a propaganda war designed to get the attention of the foreign media.

Concluding Remarks

The economy of the Philippines is mainly dependent on agriculture despite existing programmes that target industrialization. In the Philippines, 70 per cent of the population is directly or indirectly dependent on agriculture. Thus, the country had given R&D in biotechnology top priority to address the problems faced by the agricultural sector in terms of productivity, profitability, sustainability, and competitiveness in a global economy. R&D in biotechnology is done through a Biotechnology Research, Development and Extension Network as a multidisciplinary team approach of various R&D Institutions and Centers with funds provided by the Agriculture and Fisheries and Modernization Act (AFMA). The main goals of the Network are to harness the potential of biotechnology in the promotion of novel agricultural production and the post-harvest technologies, improve productivity and profitability of farm and fishery commodities, and to enhance sustainable agriculture, forestry, aquaculture, and the environment.

The Network adopted four sub-programmes, namely, genetic engineering, genomics and gene discovery, diagnostics, and socio-economics, policy and technology transfer. The country has the critical mass and infrastructure for high level R&D in biotechnology. However, these are scattered in various R&D centers and institutions. More researchers have to be trained while facilities and equipment need to be upgraded. Regulations of R&D in biotechnology is done by the National Committee on Biosafety of the Philippines using guidelines for small-scale laboratory work, for contained work and glasshouse trials, and for limited field release. Guidelines for commercialization of GMOs had been drafted and is expected to be in place within the year. Only Monsanto's Bt corn had been tested in the field. An average yield of 40 per cent had been observed. Many NGOs had called for a ban or a moratorium for field trials of GMOs. Other GM crops such as Bt cotton and transgenic papaya may be tested in the field this year. The Philippines continue to import soyabeans and corn from the US and some of these may be genetically modified. NGOs had tried to ban or stop these importations. The Philippines does not have as yet the labelling law for GM food and products.

Further Information on RDE

For more information about the Biotechnology RDE network, readers are referred to its web page: http://www.bar.gov.ph/biotech. In addition, the Network also created an e-group to establish interaction among network members and to post latest network activities. Readers are referred to the following websites:

- http://groups.yahoo.com/group/rde_biotechnetwork
- To post message: rde_biotechnetwork@yahoogroups.com
- To subscribe: rde_biotechnetwork-subscribe@yahoogroups.com
- To unsubscribe: rde_biotechnetwork-unsubscribe@yahoogroups.com
- List owner: rde_biotechnetwork-owner@yahoogroups.com

WTO, Biosafety Regulatory Regime and Trade in Genetically Modified Goods: Options before Developing Countries - An Indian Perspective

Sachin Chaturvedi*

Introduction

In recent past adoption and diffusion of biotechnology has raised several policy challenges for the governance of biotechnology especially in the developing countries. In several developing countries illegal introduction of genetically modified (GM) crops has confounded further the prevailing confusion on some of the intricate issues related to GMOs.. These discussions have important implications for both developed and developing countries, especially for those engaged in trade of GMOs. Along with this, negotiations are taking place in other institutional settings which may have impact on the international trade. There are international regulatory arrangements, like the Cartagena Protocol on biosafety and the development of multilateral, regional and national standards and regulations for the release, safety assessment and food use of genetically modified organisms.

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* Research Associate, RIS and Managing Editor, *ABDR*. Author would like to thank participants of the "International Conference on Biotechnology and Development: Challenges and Opportunities for Asian Region" New Delhi, February 26-27, 2002 for their comments on an earlier draft of this paper.
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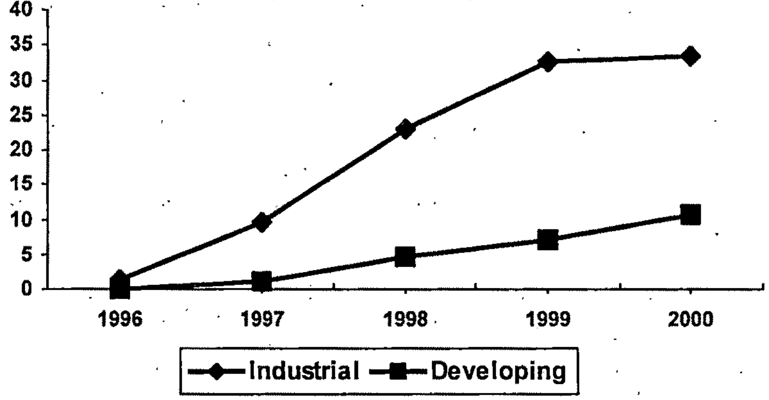
In the context of WTO, the concerns are related to various agreements which include Technical Barriers to Trade (TBT), Sanitary and Phytosanitary Measures (SPS), Trade-related Aspects of Intellectual Property Rights (TRIPs) and Agreement on Agriculture, as well as the overarching issues of market access and competitiveness.

This paper makes an effort to critically analyse each of these dimensions of international negotiations and the emerging perspectives for developing countries. Section II of the paper takes an account of the global status of biotechnology while Section III discusses at length the Cartegena Protocol and the different national regulatory regimes. Section IV analyses WTO and trade related implications, while the last section gives the conclusions.

Global Status of Biotechnology

In last few years or so, the rate of transfer of biotechnology to the field has gone up many times. Figure 1 shows the relative hectarage of transgenic crops in industrial and developing countries during the period 1996-2000. In the developed countries it went up from 1.4 million hectares in 1996 to

Figure 1: Global Area of Transgenic Crops, 1997 to 2000: Industrial and Developing Countries (million hectares)



Source: ISAAA (2001)

33.5 million hectares in 2000, amounting to a growth of 96 per cent while the proportion of transgenic crops in developing countries has only increased from 0.1 million hectares to 10.8 million hectares in the same period. The area under GMO in the developing countries grew at a rate of 14 per cent in 1997 to 16 per cent in 1998 and 18 per cent by 1999. In 2000, it showed a rise of 24 per cent. Table 1 gives the country-specific details. The total area under transgenic crops at present is 44.2 million hectares. Out of this, the USA and Canada, among the developed countries, and Argentina and China, among the developing countries, show a wider adoption of this technology. Developing countries have almost 11 million hectares under transgenic crop cultivation. Table 1 also shows that smaller Latin American and CIS countries are among other developing countries which have embarked upon the GM adoption path in the last two years. However, no agricultural biotechnology product has yet been approved in the EU. In addition, several countries including Japan, South Korea and

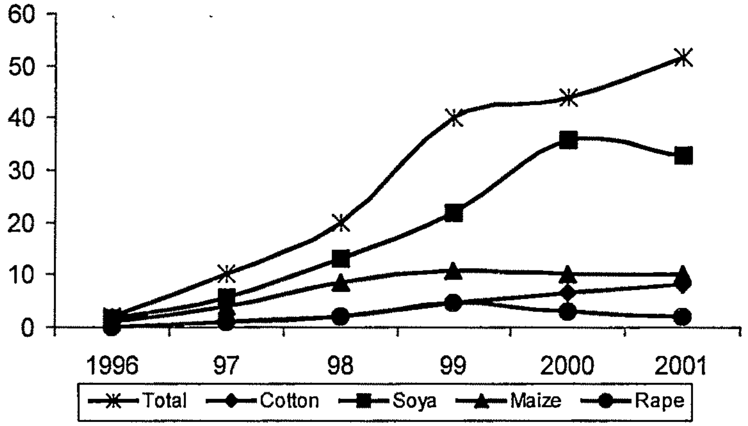
Table 1: Global Area of Transgenic Crops by Country (1996-2000)

(million hectares)

Country	1996	1997	1998	1999	2000
USA	1.5	8.1	20.5	28.7	30.3
Argentina	0.1	1.4	4.3	6.7	10
Canada	0.1	1.3	2.8	4	3
China	1.1	1.8	—	2.3	2.5
South Africa	—	—	<0.1	0.1	0.2
Australia	0.1	0.1	0.1	0.1	0.2
Romania	—	—	—	0.1	0.1
Mexico	0.1	0.1	<0.1	0.1	0.1
Bulgaria	—	—	—	—	0.1
Spain	—	—	<0.1	0.1	0.1
Germany	—	—	—	—	0.1
France	—	—	<0.1	0.1	0.1
Portugal	—	—	—	0.1	—
Ukraine	—	—	—	0.1	—
Uruguay	—	—	—	—	0.1
Total	3.0	12.8	27.8	42.5	46.9

Source: *ISAAA Briefing Papers* (Various Issues)

Figure 2: Global Area of Genetically Modified Crops (million hectares)



temporarily Sri Lanka have already passed or are considering regulations mandating labels for foods obtained from biotechnology. The details of this we would see in one of the following sections.

In the US, the biotechnology varieties accounted for about 25 per cent of the corn, 54 per cent of the soyabeans and 61 per cent of the cotton planted in the year 2000.[1] These crops are the source of various ingredients used extensively in many processed foods, such as corn syrup and soyabean oil. In Argentina the main biotechnology crop is soyabean while in Canada it is canola. Figure 2 gives details about the global area of genetically modified crops. As is clear, the total area under GM crop is 19 per cent of total cultivated area. While 46 per cent of the area under soyabean is with GM crops, the area with GM maize, cotton and rape is 7 per cent, 20 per cent and 11 per cent respectively.

The global market of biotechnology has grown rapidly in the last few years. In 1995 it was at $75 million while in 1998 it was $1.5 billion. This is now being projected to be $6 billion by 2005. This period has also seen a very rapid rise in acquisition, alliances and mergers. There are several factors responsible for these initiatives. James (1998) explains that firms having larger status in pharmaceuticals/biotechnology are now entering in agricultural sector. As a result, there has been major mergers and acquisitions among major firms world wide. Table 2 lists 25 such major acquisitions and alliances, which alone are worth $17 billion.

Table 2: Biotechnology-driven Acquisitions, Alliances and Mergers (1995-98)

Company/ Partners	**Corporations Involved/ Activity**	**Estimated Value ($ billion)**
Acquisitions and Alliances		
Monsanto	Agracetus, Asgrow, Calgene, DeKalb, Delta & Pine Land, Holdens, Sementes Agroceres, selected International Seeds Operations of Cargill, Plant Breeding International Cambridge (PBIC) (acquisitions)	8.6
Pioneer/Dupont	Joint Venture to form "Optimum Quality Products"	1.7
DuPont	Protein Technologies Inc.-soyabean miller and processor (acquisitions)	1.5
AgrEvo	PGS, Sun Seeds. Cargill North America (acquisition)	1.5
Seminis (ELM/Pulsar)	Asgrow, Petoseed, Royal Sluis, DNAP, Hungong and ChoonAng, Nath Slusi (acquisitions) LSL Biotechnologies (alliance)	1.2
Dow AgroSciences	Mycogen, Performance Plants, Brazil Hibrido & Others	0.8
Cargill/ Monsanto	R&D joint venture; $100 million per year from each	0.2
Others	Includes Crop Genomics Acquisitions and Alliances	1.5
	Total	**17.0**
Mergers		
Ciba/Sandoz	Novartis created, with seed/pesticide sales of approximately $5 billion	5.0
Hoechst/ Rhone Poulenc	Aventis created, with agricultural sales of AgrEvo and Rhone Poluenc Agro exceeding $ 4.5 billion annually	4.5
Zeneca and Van der Have	ADVANTA with annual sales of seed plus pesticides from Zeneca of approximately $3.5 billion	3.5
	Total	**13.0**

Source: *ISAAA* (1998)

There were three major mergers worth $13 billion. As the list of acquisitions shows, Monsanto has emerged as the biggest player in the game. In the process, it has acquired some of the largest firms in the US commodity markets and holds important patents. For instance, DeKalb has 11 per cent of US commodity market with lots of important patents. Similarly, Delta & Pineland is the largest US company for cotton seeds. Monsanto has also acquired international seed operations of Cargill for $1.4 billion. Cargill specialised in seeds of corn, sunflower, rapeseed, soyabean, alfalfa, sorghum, wheat and hybrid rice in 51 countries. Unilever owned Plant Breeding International Cambridge Ltd. (PBIC); earlier a public research institute had also been bought by Monsanto. PBIC largely focuses on cereal varieties and potato. Among the mergers one finds creation of Novartis is a major step towards tapping of synergies in the biotechnology business. Ciba and Sandoz have merged their pesticide and seed business of $5 billion to take form of Novartis. Similarly, the purpose of the merger of Hoechst and Rhone Poulenc to form Aventis was to achieve better operational efficiency. Aventis now has an R&D budget of $3 billion and annual sales of $ 20 billion all over the world.

Biotechnology offers several ways by which average yields can be directly increased. One such way is through improvements in the "architecture" of the plant to enable it to absorb more photosynthetic energy or convert a larger portion of that energy into grain rather than through stem or leaf. This was, in essence, the "Green Revolution" approach of breeding dwarfing genes into plants so that the plants could make better use of fertilizer and water and produce more grain. This approach is being pursued again in the new rice architecture being studied by the International Rice Research Institute (IRRI), Manila, as well as by some private sector interests undertaking research in the fundamental mechanisms that control plant architecture. Another approach is to modify the plant for a shorter growing season by enhancing its efficiency in the use of fertilizer, pesticides and water for climates where this is useful. Molecular hybridization has also been demonstrated to increase the productivity of several crops, including rice and wheat, by 15 to 20 per cent.[2] It must be noted that the on-farm yield improvements observed so far have been for transgenic varieties developed to reduce on-farm production costs rather than for the purpose of increasing yields.

However, it is not yet clear whether yield increasing experiences gained so far reflect a one-time advance, or reveal the first stage of a continuing increase in yields. Considering that there are many new technologies that will, over time, be applicable for plant improvements and/or integrated into plants, the most reasonable conjecture is that the new technologies will continue to provide yield increases, that these will be introduced on a regular basis, and that each of the associated yield increases will be somewhere more than the historical trends.[3] There are many possibilities by which biotechnology improves the nutritional value of cereals by enhancing the presence of special nutrients or chemicals. A commercial example is the increase in the levels of biotin (vitamin H) for application in animal and human nutrition.

Biotechnology has been targeted at rice and it has been tried to improve upon rice to meet the vitamin A and iron deficiencies. Vitamin A deficiency, which also interferes with the bio-availability of iron, affects 413 million children worldwide, i.e. 7 per cent of the world population. Rice endosperm does not contain any pro-vitamin A. However, through different techniques transgenic plants, carrying the genes, produced seeds with yellow endosperm. The biochemical analysis has confirmed that this yellow colour indicates the presence of pro-vitamin A.[4] Public sector breeders have also been looking into similar special purpose applications, such as inserting genes so that vitamin A and iron become available through the consumption of rice.[5]

Among the potentially more important applications for specific markets are those that seek to improve the quality of feed crops. New varieties of transgenic maize that contain higher oil levels to boost energy and improve feeding efficiency or have characteristics to reduce phosphorous in animal waste are examples that are currently under development.[6] In an interesting development, a patent has been granted, covering the insertion of a protein into plants, which, when eaten, would check growth of animal parasites in human body. Biotechnology in food grains has mostly addressed development of a single trait only. This has remained confined to herbicide and pesticide tolerance only. However, recently some companies like Garst Seeds, a subsidiary of Advanta, have developed maize hybrids, which can tolerate two different classes of chemical herbicides.[7] In the United States, currently about 20 per cent of the maize production is destined for industrial production. This has become possible with the production of high-fructose corn syrup and of alcohol being the largest of a number of the industrial uses.[8] Maize and sorghum are among the crops that produce a high yield of starch/energy per hectare, and are the leading temperate zone crops for this purpose. In essence, it has become possible to vary the feed or starch production characteristic of important crop plants within wide bounds, making it possible to use almost any starch producing plant for different industrial purposes.

There are also other non-traditional uses of cereal crops. The most important example of which is cellulose, clearly available from other sources, but perhaps usefully produced in grain cultivation under certain circumstances. These developments may have significance for rice and other cereals, which are more widely grown in developing countries. To the extent that imported cereals are priced higher than those domestically grown, using starch and other traits from domestically produced bio-engineered cereals in developing country, industries could give lead to cost savings and thereby boost the farm incomes. Another important possibility is genetically altered crop plants for the production of proteins of pharmacological significance. Some of the patens in this area have wide applicability to different products, including, for example, to the production of maize. Several of the patents mention production of specific products, not all of which are therapeutic. However, commercial applications of these technologies are not yet widely available.

Cartagena Protocol and National Regulatory Regimes

At the global level there are two broad sets of regulatory regimes which have become part of agricultural biotechnology. One set emanates from national regulatory mechanisms evolved during last one decade and the other from the recently concluded Cartagena Protocol. The former, apart from having individual countries, also have groupings like the EU which have proposed to establish regulations requiring documentation to trace the presence of biotechnology products through each step of grain handling and food production processes. In fact, the EU now has also proposed to apply similar regulations for animal feeds.

The Cartagena Protocol on Biosafety was adopted by the Conference of the Parties to the Convention on Biological Diversity on 29 January 2000. The Protocol has been signed on behalf of 107 States and regional economic integration organizations while very few have ratified it. Kenya is the 12th country to have ratified the Protocol in January 2002. The Protocol would become effective only after 90 days of the 50th ratification The list of the countries, which have ratified the Protocol, is given in Table 3. India has not ratified this till now.

After five years of intense negotiations governments have finalized a legally binding agreement for protecting the environment from risks posed by the

Table 3: Cartagena Protocol on Biosafety: Ratifications

Country	Signature Date	Ratification Date
Bulgaria	24 May 2000	13 October 2000
Czech Republic	24 May 2000	8 October 2001
Fiji	2 May 2001	5 June 2001
Kenya	15 May 2000	24 January 2002
Norway	24 May 2000	10 May 2001
Spain	24 May 2000	16 January 2002
The Netherlands	24 May 2000	8 January 2002
Uganda	24 May 2000	30 November 2001

Source: www.biodiv.org/biosafety/signinglist.asp/

transboundary transport of living modified organisms (LMOs)[9] usin modern biotechnology. Under the Cartagena Protocol on Biosafety governments, by communicating their decision to the world communit via an Internet-based Biosafety Clearing House, will signal whether or no they are willing to accept imports of agricultural commodities that includ LMOs. In addition, shipments of these commodities that may contain LMO are to be clearly labelled. LMOs include various food crops that have bee genetically modified for greater productivity or nutritional value, or fo resistance to pests or diseases. Common examples include tomatoes, grains cassava, corn, and soyabeans. Seeds for growing crops are particularl important because they are used intentionally to propagate or reproduc LMOs in the environment. Together, these agricultural LMOs form th basis of a multi billion dollar global industry. Pharmaceuticals derived using LMOs, form the basis of an even larger industry (althoug pharmaceuticals are not covered by this agreement).

Stricter 'Advanced Informed Agreement' (AIA) procedures will apply t seeds, live fish, and other LMOs that are to be intentionally introduce into the environment (Article 7.2). In these cases, the exporter mus provide detailed information to each importing country in advance o the first shipment, and the importer must then authorize the shipment The aim is to ensure that recipient countries have both the opportunit and the capacity to assess risks involving the products of moder biotechnology. Moreover, the information should also include th modifications introduced in the technique used and the resultin characteristics of the LMO, the regulatory status of the LMO in the countr of export, and the contact details of the importer and the exporter. Th notification has to be accompanied by a risk assessment report. Anothe important feature of the Protocol emanates from Preamble and Articles 1 10 and 11. This is "precautionary approach". This means that if there i scientific uncertainty about the impact of genetic manipulation o biodiversity and human health then the importer country may enforc restriction on imports and this flexibility would remain till an importe on his own arrives on scientific certainty about implications.

One of the most contentious issues that negotiators had to resolve involved the relationship between the Protocol and the other international agreements, notably those under the WTO. While the environmental agreements are premised on the precautionary principle (which states that potentially dangerous activities can be restricted or prohibited even before they can be scientifically proven to cause serious damage), decisions under the trade law require "sufficient scientific evidence". While the Protocol and WTO agreements are to be mutually supportive, the Protocol will not affect the rights and obligations of governments under any existing international agreements.

Regulatory Regime at National and Regional Levels

Over the years, the regulatory regimes have emerged in different countries at different pace and have taken different directions. The national responses have largely been driven by specific national situations. For instance, "mad cow disease" situation in Europe led to an extreme consumer rigidity for genetically modified food. Table 4 briefly depicts the evolution and current shape of biosafety policy across the countries.

The European Community (EC) introduced an approval system for the deliberate release of GMOs in the environment. In the following years the labelling of GMOs was made mandatory. This included foodstuffs and food containing additives or flavouring that have been genetically modified. Gradually even animal feed has been made mandatory to be labelled. These initiatives of the EU have created a big public debate across the world. However, the European Commission reserves the right to support biotechnology research. The Commission has also acknowledged that Europe's biotechnology industry is lagging behind. In fact, a four-prong strategy has been worked out to catch up in this technology race.[10]

Japan has also come out with stringent regulations. A committee in charge of developing rules for biotechnology labelling was appointed in 1997 under the Ministry of Agriculture, Forestry and Fishery (MAFF). This

Table 4: The Regulatory Framework Regarding GMOs: Selected Countries

EU	1990	- EC introduced an approval system for the release of GMOs into the environment for experimental and commercial purposes.
	1997	- EC made labelling mandatory for a product containing GMOs.
	1999	- EC provided consent to place GMOs in the market for a limited period on the condition of compulsory monitoring.
		- Labelling requirements extended to include foodstuffs and food containing additives or flavouring that have been genetically modified.
	2000	- A directive was introduced that will include a requirement for animal feeds to be labelled.
		- Need for prior consent of third countries that are importing GMOs.
	2005	This is set as a definitive date for phasing out the use of GMOs that are resistant to antibiotics.
Japan	1999	- Japanese government recognized 22 GMOs as "safe products". All imports containing GMOs other than the approved ones to be rejected.
	2000	- Japan introduced mandatory labelling requirements for final products containing GMOs.
		- Japanese government circulated the official definition of organic farm products. GM products are among the products that cannot be labelled as organic.
United States	1996	- US government approved some 50 varieties of genetically modified crops.
	1999	- A bill requiring labelling of all genetically modified entity was introduced, but the issue remained unresolved.

Table 4 continued

Table 4 continued

	2000	- A proposal was introduced by the FDA under which biotechnology industry would notify them four months in advance before marketing a new GM product and provide evidence of the safety of that product. This, however, is not mandatory. It is to be followed on a voluntary basis. - The FDA released its proposed final rule for definitions of organic foods. Any food labelled 'organic' could not be developed using GMOs.
New Zealand	1999	- A pre-market safety assessment to be carried out by the food authority before genetically modified food are sold. - Introduced labelling of such products.
Australia	1999	- A pre-market safety assessment to be carried out by the food authority before genetically modified food are sold. - Introduced labelling of such products.
Canada	1999	- The Canadian Council of Grocery Distributors agreed to develop a voluntary GM food labelling regime.
Thailand	1994	- Thailand's legislation on plant quarantine was expanded to cover GMOs. Under this, the release into the environment and the import of GM seeds and crops was subject to strict approval system.
	2001	- The Thai food authority intends to impose labelling requirements.
Sri Lanka	2001	- The National Food Advisory Committee banned the imports of GMOs and GM foods but later withdrew it.
Republic of Korea	2000	- Passed a legislation regarding mandatory labelling of genetically modified soyabeans, corn, and soyabean sprouts.

ministry has announced to introduce mandatory safety checks to guard against imports of unapproved genetically modified crops for human consumption as well as animal feed.[11] This has set in almost a zero tolerance for food imports containing unapproved gene spliced products.

As the global debate over the benefits and safety of genetically modified food rages on, China has passed regulations that require clearer labelling of these types of products. Now it is being proposed that by the end of March 2002 China would introduce mandatory labelling of food. China's State Council considered and passed the regulations concerning the biotech safety management of agricultural gene alteration. In the past, when crops with genetic alterations graduated from the laboratory to the field, they had to be approved by the Ministry of Agriculture. However, when they were transformed into merchandise, there were no such regulations. The new legislation, for example, will regulate the biological products with gene alterations requiring the above-mentioned food labelling, so that the issues related to gene alteration can meet international standards.[12]

In India, though biosafety policy evolved only in the last decade, it has yet to address trade related issues. The policy was announced in 1990 and has subsequently been revised at least five times. One of the recent controversies, which highlighted this lacuna, was related to import of genetically modified soyabean from the US by a donor agency serving food programme for children.[13] India's Biosafety and Recombinant DNA Guidelines (1990) fall under the Environment (Protection) Act of 1986. In 1994, after India signed the Convention on Biodiversity, the DBT revised its earlier guidelines to accommodate the safe handling of GMOs in research application and technology transfer. This includes the large scale production and deliberate release of GMOs plants, animals and products into the environment. Guidelines are also provided for the shipment and importation of GMOs for laboratory research.

Unlike many other countries, in India there is no permanent secretariat to monitor the trials of the GMOs. Instead, the regulations are implemented by various ad hoc committees. The most important committees for this purpose are the Institutional Biosafety Committees (IBSC), responsible for the local implementation of guidelines; the Review Committee on Genetic Manipulations (RCGM), responsible for issuing permits; and the Genetic Engineering Approval Committee (GEAC), responsible for monitoring the large scale and commercial use of transgenic materials. These committees have statutory authority. Most of the committee members are from the scientific community and staff of Department of Biotechnology (DBT) and the Ministry of Environment and Forest, Government of India. DBT appoints the members to the committees. The GEAC is supposed to be assisted by the State Biotechnology Coordination Committees (SBCCs) and District Level Committees (DLCs). However, none of the 26 Indian states has established SBCC and DLC committees, not even in the areas where field trials are already taking place. Moreover, while committee members are drawn from the scientific community, many are not well versed in biosafety issues and risk assessment.

Provisions in WTO Agreements

The issue of GMO possibly spans several WTO agreements, including Sanitary and Phyto-Sanitary Measures (SPS), Agriculture, Intellectual Property (TRIPS) and Technical Barriers to Trade (TBT). GMOs have also been discussed in the Trade and Environment Committee. Although member governments have notified a large number of regulations related to GMOs to the SPS Committee, most of the discussion on the subject has been in the TBT Committee, with the focus on labelling regulations. In the current agriculture negotiations, some members have called for clarity in WTO rules, as applied to products of new technologies.

The SPS Committee, which met on 31st October and 1st November 2001, discussed for the first time the genetically modified organisms. In considering notifications for the first time in the SPS Committee, the US and Canada enquired about the EU's restrictions on genetically modified organisms (GMOs). They complained that the EU had failed to notify its latest directives on traceability and labelling under SPS, even though these indicate that health protection is one of the objectives. Under "other business", the US also complained about the lack of scientific justification for the EU's continued *de facto* moratorium on approval of GMO products, and Canada raised the issue of the latest EC measure discriminating against products produced by GM technology, even where no trace remains in the final products.

In the TRIPS Committee it is the Article 27 which has remained the centre of focus. Article 27 of the TRIPS Agreement defines the types of inventions which have to be eligible for patent protection and those which can be exempted. These include both products and processes, and they cover all fields of technology.

Article 27.3(b)) covers biotechnological inventions. It is currently under review in the TRIPS Council, as required by the TRIPS Agreement. Some countries have broadened the discussion to cover biodiversity and traditional knowledge. India and many other developing countries have been demanding an explicit position on benefit sharing on traditional knowledge system. The Doha Ministerial statement says:

"We instruct the Council for TRIPS, in pursuing its work programme including under the review of Article 27.3(b), the review of the implementation of the TRIPS Agreement under Article 71.1 and the work foreseen pursuant to paragraph 12 of this declaration, to examine, *inter alia,* the relationship between the TRIPS Agreement and the Convention on Biological Diversity, the protection of traditional knowledge and folklore, and other relevant new developments raised by members pursuant to Article 71.1. In undertaking this work, the TRIPS Council shall be guided by the objectives and principles set out in Articles 7 and 8 of the TRIPS Agreement and shall take fully into account the development dimension."

Broadly speaking, the Article 27.3(b) allows governments to exclude plants, animals and "essentially" biological processes (but micro-organisms, and non-biological and microbiological processes have to be eligible for patents). However, plant varieties have to be eligible either for patent protection or through a system created specifically for the purpose ("sui generis"), or a combination of the two. For example, countries could enact a plant varieties protection law based on a model of the International Union for the Protection of New Varieties of Plants (UPOV). The review of Article 27.3(b) began in 1999 as required by the TRIPS Agreement.

The issues raised in the TRIPS Council included pros and cons of various types of protection for new plant varieties (patents, UPOV, etc); handling moral and ethical aspects (e.g. whether invented life forms should be eligible for protection); dealing with traditional knowledge and the rights of the communities where genetic material originates (including benefit sharing when inventors in one country have rights to creations based on material obtained from another country) and conflict between the TRIPS Agreement and the UN Convention on Biological Diversity (CBD). In the meeting India suggested that patent applicants should disclose the origin of genetic material used, which would make benefit sharing easier to implement. India has also emphasized on benefit sharing through prior agreement between the researchers and the host country where the genetic material originates, instead of the disclosure in patent applications which is difficult to enforce.

However, some countries are seeking clarification on issues such as the meaning of the term "micro-organism" and the difference between "biological" and "microbiological" processes. Some countries say life forms and living creatures should not be patented and that ethical questions should also be discussed. Some developing countries proposed to ensure that the TRIPS Agreement takes account of more specific concerns such as allowing their farmers to continue to save and exchange seeds that they have harvested, and preventing anti-competitive practices which threaten developing countries' "food sovereignty". At the Committee on Agriculture this issue came up again in the same context. In July (2001) at the special session of the Committee on Agriculture, the European Union tabled a paper on food safety, proposing criteria for the application of precaution under the Agreement on Sanitary and Phytosanitary Measures (SPS) that should serve as a guideline for panelists in future disputes.

According to the EU, the issue needs to be addressed to avoid the public perception that the WTO requires members to force consumers to accept unsafe food. The EU, other European countries, Japan and South Korea argued that Article 5.7 of the SPS Agreement should be clarified through an understanding that would send the right signals to consumers. Article 5.7 allows members to take provisional health measures when relevant scientific evidence is insufficient, and the substance of the discussions revolved around whether the Article was clear enough to maintain the balance between the need for consumer protection on the one hand and the need to avoid disguised protectionism on the other.

To create predictability for members and to prevent Article 5.7 from being abused for protectionist purposes, the EU proposed that precaution be applied according to the following five criteria: (i) the measure should not be discriminatory; (ii) it should be aimed at achieving consistency in the level of protection that the Member has chosen; (iii) the adopted measure should presuppose an examination of the benefits and costs of action and lack of action; (iv) it should be reviewed if new scientific information is obtained; and (v) the measure must be based on scientific evidence provided by qualified and respected sources, but not necessarily by the majority of the scientific community. The US and many developing countries strongly opposed this effort to bring food safety onto the agriculture negotiating agenda. They argued that the EU's version of the precautionary principle was based on political rather than scientific considerations. Suspecting that the EU was chiefly interested in finding another avenue for addressing the controversial precautionary principle in the WTO, the US, the Cairns Group and India insisted that instead of the agriculture negotiations, the food safety should be discussed at the SPS and the TBT Committees.

Impact of GM Goods on Trade

Though international trade regime at the WTO has yet to address challenges emanating from advancements in biotechnology in a comprehensive manner, the prohibitive measures have already started affecting the trade. Table 5 shows how US exports of corn and soyabean have declined in several of those countries which have resorted to these prohibitive tactics. In 1997 import of corn from European Union was 1000 metric tonnes which declined to 0.07 metric tonnes by 2000. Similarly, import of soyabean from EU has declined from 8000 metric tonnes in 1997 to 6000 metric tonnes by 2000. Apart from this, delays in authorization to import Bt corn from the US by France cost US exporters about $300 million in exports to the European Union.[14] Only about 2 million tonnes of the 42 million tonnes of US corn exports went to the EU in 1997. In 1998 alone 0.3 million tonnes of the 41 million tonnes went to the EU. Factors that have been used to explain the levels of decline include ban on GM corn by France, Austria and Luxemburg.[15] Similar declines have been documented for soyabean also. Only 9 million tonnes (out of 26 million tonnes) of US soyabean exports went to the EU in 1997 and 6 million tonnes (out of 20 million tonnes) of soyabean was exported to the EU.

India has recently gone through very tough time in terms of governance of biotechnology.[16] Genetically modified cotton has already been illegally introduced in the production system which is all set to create problems with those countries in which imports of GM variety are banned – a problem similar to what we saw in the case of the US. However, as Table 6 shows, the total impact on exports of only those crops, in which biotechnological applications have been planned, for instance, cotton, corn, soyabean and vegetables, for only three countries would be $6201 million. It would nearly be $1700 million to the EU alone. The confusion is further confounded when one finds that there are very few equipped laboratories in which GMO testing can be done. Therefore, a clear market strategy and options with technological choices would have to be made with lot of precaution.

Table 5: US Exports of Corn and Soyabeans to Selected Regions/Countries, 1997-2000

	Corn (10^6 metric tones)*			Soyabeans (10^6 metric tones)		
Region/ Country	1997 Jan-Dec	1999 Jan-Dec	2000 Jan-Dec	1997 Jan-Dec	1999 Jan-Dec	2000 Jan-Dec
Africa	3.95	6.69	6.46	0.11	0.28	0.23
Asia	27.68	31.45	26.73	11.68	12.14	14.94
European Union	1.56	0.09	0.07	8.96	6.46	6.10
Japan	15.45	15.33	14.87	3.70	3.68	3.58
South Korea	3.44	6.16	2.29	1.25	1.17	1.34
Canada	1.03	0.97	1.49	0.26	0.33	0.33
China (Taiwan)	5.44	4.73	4.72	2.27	1.95	1.93

* 1 metric ton = 2,204 pounds.

Source: ERS/ USDA. FATUS Report. Available online at http://www.ers.usda.gov/db/fatus/

Table 6: India's Exports of (Potential GM) Crops

(US Dollar Million)

	Cotton	**Corn**	**Soyabean**	**Vegetables**	**Tot Crops imported by countries**	**% Share In Total Exports of Crops**
EU	1725.64 (28.99)	0.05 (2.27)	0.08 (32.00)	41.44 (16.77)	1767.21	28.50
Japan	161.79 (2.72)	—	0.11 (44.00)	1.36 (0.55)	163.26	2.63
South Korea	189.03 (3.18)	—	—	0.52 (0.21)	189.55	3.06
Total	5951.7	2.2	0.25	247.07	6201.22	100.00

Source: India Trade 2001.

Note: Figures in Parenthesis are percentage share in total exports.

Concluding Remarks

The above analysis shows that it is desirable that developing countries should make choices in the biotechnology at selective levels. Even within agricultural biotechnology there are several options which take the horizon far ahead of adoption and diffusion of GMOs. This decision should be subject to a critical evaluation of the need assessment of developing countries. In order to obtain benefits and be competitive in biotechnology, developing countries need to access not only the products, but more importantly the technology and certainly the tool for it. In addition, access to genetic resources and the associated traditional knowledge plays a vital role, highlighting the need for benefit sharing and prior informed consent.

There has to be a multilateral effort to help build capacity related to institutions, infrastructure, policy development and implementation, human resources, local-level ecological data, and research and development in the developing countries in general and in underdeveloped countries, in particular. These countries also require support to adopt GM product along with provisions for its safe use and capability to handle its imports and exports. As far as international negotiations are concerned, a strategy, founded on well-informed opinion on technical aspects, should be evolved. This includes participation in international negotiations at the WTO and international standard-setting organisations level.

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Beijing Genomics Institute (BGI): A Report

At the International Conference on Biotechnology and Development (February 26th and 27th) organised by RIS at New Delhi, Dr Bin Liu, Head of Research and Collaborations at the Beijing Centre of Genomics and Bioinformatics Institute of Chinese Academy of Science, presented a report on the current advances in genomics in China and the emerging role of Beijing Genomics Institute (BGI). During his visit, RIS also organised his lectures at the Department of Biotechnology, Government of India and at the Life Science Department of Jawaharlal Nehru University (JNU) at New Delhi. Here we are giving a brief report on BGI.

– Managing Editor

The Beijing Genomics Institute is the largest non-profit genomics research institute in China. This was established in July 1999 by a group of overseas Chinese scientists. BGI has been growing rapidly with the support from the Chinese Academy of Sciences. With over 600 employees, BGI has two campuses with the main one in Beijing and one in Hangzhou City opened in January, 2001. China is the only developing country among the six countries in the International Human Genome Project Consortium and China's BGI played a leading role in completing the part of chromosome 3 assigned to it. This work has won a good reputation in the international genomics community.

In the year 2001, Sun Enterprise, a major software company, chose the Beijing Genomics Institute (BGI) of China as a Centre of Excellence (COE) based on its advanced work in genomics, alternative splicing algorithms and proteomics. The BGI team will use two Sun Enterprise (TM) 10,000 supercomputers to study rice and porcine genomes, among other projects. Computing technology and genomics are both rapidly advancing fields. Working with Sun as a COE will give BGI an opportunity to put its work at the cutting edge of both of these emerging disciplines.

The Human Genome

BGI was launched to participate in the international Human Genome Project (HGP). In September 1999 China was allocated to sequence part of chromosome 3p. The related team coordinated with two Chinese National Human Genome Centers at Shanghai and Beijing. Then BGI organized the first large-scale genome-sequencing project in China. The China group completed 42Mb of human genome draft with high quality. Although this only encompasses about 1 per cent of human genome, this made China as one of the major players in the international genomics arena, and BGI one of the six major genome centers in the world. US president Bill Clinton acknowledged China's contribution in his Whitehouse press conference announcing the human genome draft.

Rice Genome Project

BGI has completed the *indica rice* genome working draft. The rice genome scaffold was assembled by a new assembly algorithm and on supercomputers. In the agricultural sector having a major crop genome sequenced after the human genome is a major achievement. The work was first published in 'Science in China' then 'Science'. BGI team sequenced a high-yield "Super Hybrid Rice" derived from a rice variety indica, while the international rice genome project uses a different subspecies japonica. A Chinese breeder Dr. Yuan Rongping cultivates this over twenty years, the Super Hybrid Rice has a very high yield. The working draft has a six-fold coverage with over 95 per cent gene coding region identified. The finishing of the genome is projected to be completed in 2002. Meanwhile, BGI will start the comparative genome study between maternal (PA64S) and the heterosis offspring and gene prediction. Genetic markers including SNP will be developed. Genes responsible for high yield, blast resistance and conditional sterility will be identified, leading to development of new cultivar.

Other Genome Sequences

This was the first BGI genome sequencing project completed in 2000. Thermoanaerobacter tengcongensis is a rod-shaped, anaerobic and extremely thermophilic eubacterium isolated from fresh water hot springs in Tengchong of Yunnan Province, China. BGI has sequenced and fully assembled its circular genome of 2,689,445 base pairs, using a "whole-genome-shotgun" approach. The analysis has identified 2,588 predicted open reading frames with 1,764 (68.2 per cent) having functional assignments. The classification of genes in molecular functions and metabolic path ways reveals that this thermo-bacterium utilizes sugars as principal energy and carbon source, and gains energy anaerobically by sulfur respiration. Out of the sequenced eubacterial genomes, the genome of T. tengcongensis is the most similar to that of a mesophilic eubacterium, Bacillus halodurans, where 54.4 per cent of their genes are orthologous. The work has been published on Genome Research in 2001.

BGI and the Danish Porcine Genome Consortium launched the Porcine genome sequencing project in October, 2000. The project, expected to take several years, is the first to tackle livestock. The Danish consortium includes the Danish Institute of Animal Sciences, the Royal Veterinary and Agricultural University (KVL), and representatives from Denmark's pig industry. The partners hope that information from the project will benefit pig-breeding industries in both the countries as well as the basic science and medicine. BGI will carry out the sequencing and sequence analysis work. In Phase I, the project is aimed at identifying the valuable genes to develop markers for physical and genetic mapping, and provide research tools for xenotransplantation in three years. The second phase would develop a working draft covering 90 per cent of the sequence and 95 per cent of the genes. The pig genome is estimated to contain 3 billion base pairs, roughly the same size as human.

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Chinese team makes public novel rice genome sequence

The *Oryza sativa indica* strain, which accounts for the majority of rice grown in China, has never before been sequenced. Preliminary results of the Beijing Genomics Institue (BGI) project, begun in May 2000 and completed in October 2001, was published in the *Chinese Science Bulletin* when its draft was complete. However, the extent of the work remained virtually unknown outside a cadre of Chinese genomics researchers until the team presented their findings. BGI researchers sequenced the *indica strain* using a whole genome shotgun approach, according to Jun Yu, a member of the team. The effort yielded 386 million base pairs in a six-fold coverage, and an initial analysis by BGI researchers showed that the genome contains approximately 60,000 to 65,000 genes. The effort, which independent researchers are only now beginning to analyse, is the first rice genome to be released to the public.

Recently Syngenta and Myriad Genetics also announced the draft sequencing of the *japonica strain*, but the companies have yet to release those data. An international public consortium, the International Rice Genome Sequencing Project (IRGSP), is set to finish its own sequence of the *japonica genome* by the end of 2002, according to scientists close to the project. The IRGSP, which includes the United States, Japan, and China, is performing the sequence approach which when compared with whole-genome shotgun sequencing is more time-intensive.

Source: RIS based on www.checkbiotech.org, 18 January, 2002.

EU needs venture capital market for biotechnologies

According to the European Commissioner, Mr. Erkki Liikanen creating a pan-European venture capital market is crucial to helping the continent's nascent biotechnology sector catch up with its better financed U.S. counterpart. European governments must also play a role in educating the public about the safety of genetically modified foods if biotechnology companies are to exploit this market culture. Mr. Liikanen, of Finland, was the leading public figure at the EU's first informal seminar of ministers of industry and research at Barcelona. Among their tasks is elevating the cutting-edge field of biotechnology, listed as a priority in the EU's plan to make Europe the world's most competitive economy by 2010. The field brings together life sciences, material sciences and information technology with application in the pharmaceutical, manufacturing, food and environment industries.

Although European biotechnology companies out number those of the United States by 1570 to 1273, the American firms boost three times the stock market worth and generate three times the revenue as 23 per cent of them are publicly listed as against only 6 per cent of those in Europe. The European industry is acknowledged to be behind the American counterparts by four or five years, according to President Romano Prodi s estimates. There were just four European biotechnology IPOs in 2001 after a record 39 in 2000. Such lacklustre performance has shut many companies out of the bull market. The EU must also improve regulation, intellectual property rights and education, Liikanen said.

Source: RIS based on www.checkbiotech.org, 5 February, 2002.

A Codex standard mandating "GMO labelling" of food products

An examination of current agricultural production practices reveals that foods produced prior to the advent of the new biotechnology had significant risk inherent in their creation and production.

According to the United Nations Food & Agriculture Organisation (FAO), 25 per cent of the world's food grain crops are infested with mycotoxins each year, and an annual loss of millions of tons of foodstuffs is a direct result. Mycotoxins are a group of toxins (metabolites) naturally produced by certain fungi that can infect some crop plants (primarily corn), and cause cancer in humans that consume them. Chief among those mycotoxins is aflatoxin B1, the most potent cancer-causing agent known to mankind. Aflatoxin swiftly appears in milk after a cow ingests it, so humans can consume aflatoxin in both milk and grains. According to a 1993 World Bank report entitled *Investing in Health*, approximately 40 per cent of disability-adjusted life years (premature death and disability) in developing countries are lost due to diseases linked to mycotoxin consumption (e.g. liver cancer).

Biotechnology-derived "Bt corn" has been repeatedly shown to dramatically reduce the production of mycotoxins in corn in the field. The primary vectors for carrying into corn plants the particular fungi that produce aflatoxin and other relevant mycotoxins in corn are the very insects (e.g., corn borer/ostrinia nubilalis) best controlled by "Bt corn", Bt corn and other Bt crops hold the potential to "reduce or even eliminate mycotoxins in the food supply." According to the head of the World Health Organisation's (Codex) Food Safety Programme, "Bt corn (maize) which reduces insect damage and in turn the amount of mycotoxins in food raw materials can have a direct impact on the reduction of (the world population's) live cancer.

Ever since the EU enacted its mandatory food "GMO labelling" law, food retailers and food product manufacturers have reduced their inclusion of products containing the relevant (substantially equivalent) biotechnology commodity ingredients. For example, England's sixth-largest food retail chain (Iceland Plc) "took out all biotechnology soya" from its entire line of private brand foods. Group Danone SA, Europe's third-largest, "banished genetically modified ingredients" from all its products in Europe. Britain's two largest food retailers, plus McDonald's restaurant (in seven European countries) have demanded that their poultry and pork suppliers guarantee that genetically modified feed ingredients have not been used in the animal feed used in their own-brand meat production. Similar dramatic reductions have occurred in Japan, since the Japanese government first began creation of Japan's "GMO labelling" law (not implemented yet). For example, Japan's largest maker of soyabean protein food products, plus Japan's three largest beer brewers publicly declared they would halt using any genetically modified ingredients.

While it may be hoped that food manufacturer fears of putting a biotechnology message on a foodstuff will subside, there is no evidence to date to give one such hope. And as long as anti-biotechnology activists continue efforts to raise fears among consumers about the safety of biotechnology crops, food manufacturers are likely to continue to want to avoid labelling through reformulation of ingredients or by seeking out non-biotechnology supplies. The perverse result, from a food safety standpoint, is that food manufacturers and consumers will be driven to less safe options as a result of a mandatory GMO labelling Codex standard. Such a result would undermine Codex's goals to improve food safety.

Adoption of a mandatory "biotechnology labelling" standard may not only drive manufacturers and consumers to less-safe alternatives, but it would also increase consumer costs. Numerous studies show that "segregating" the non-biotechnology commodities out of the (naturally mixed) commercially mainstream is impractical and costly.

For example, a Canadian food industry study recently estimated that the labelling alone would increase Canadian retail food costs by 9-10 per cent and that estimate did not include the costs for inevitable mis-labelling product recalls (estimated to be approx. 100 annually). A similar study, funded by the European Commission, estimated that European retail food costs would increase by 6-17 per cent.

In January of 2001, Dow Chemical Company signed a research and licensing agreement with EPIcyte Pharmaceuticals Inc. "to develop and produce monoclonal antibodies in plants... directed at emerging opportunities for disease prevention... and the safety of the animal-derived human food supply". Private conversations with applicable industry participants have identified one goal of that partnership to be genetic engineering of crop plants containing antibodies directed against meat-borne pathogens such as *escherichia coli* 0157:H7. The concept of eliminating all pathogenic *escherichia coli* strains from a living animal's digestive system via the feeding of antibodies had already been proven earlier, via feeding of such antibodies in egg-whites to baby piglets (prior to development of their digestive systems). However, the feeding of such egg-white-antibodies to adult livestock (e.g., during the two days prior to slaughter) is not feasible, because their digestive system would destroy the antibodies before they reached the pathogenic bacteria (i.e. *e.coli* O157:H7) in their intestines.

Source: RIS based on www.checkbiotech.org, 5 February, 2002.

CGIAR under pressure to support seed treaty

The aim of the seed treaty is to provide effective legal rules to free up the exchange of seeds between countries for breeding and GM crop development, but the issue of plant genetic resources has been heavily influenced by the non governmental organisation (NGO) campaign against biopiracy. Policy analysts say the result is an ambiguous text that could actually jeopardize the equitable use of germ plasm and, once ratified, could herald a significant loss of autonomy for Consultative Group on International Agriculture Research (CGIAR) centers and burden them with overwhelming responsibilities.

There has been a slump in growth of global seed collections and access to them since the early 1990s, when many gene banks simply thought that they had sufficient samples after 20 years of collecting. The problem was exacerbated at the time by an NGO-fuelled anti-biopiracy campaign, which resulted in national laws (based on the Convention on Biological Diversity) restricting access to many seed collections – a point the FAO has focused on in pushing for this treaty.

The new treaty establishes a communal collection of 35 food and 29 feed crops (called the Multilateral System), samples of which are to be provided by the national gene banks of ratifying countries. The CGIAR, which was set up to secure food and eradicate poverty in developing countries, supports 16 International Agricultural Research Centres (IARCs), and article 15 of the treaty explicitly calls upon IARCs to place their samples (over 600,000) in the treasury.

To encourage gene-rich developing countries to participate, any company that commercializes a new variety developed from a sample in the Multilateral System will have to pay a royalty into a fund to benefit members and preserve biodiversity. However, the details of tax tariffs, benefit sharing, and how all of this will be policed are not addressed in the treaty, and a Governing Body of representatives of ratifying countries is to be set up (when the treaty comes into force) to work out these and other issues.

As such details are unclear, some developing countries have refused to include their most valuable crops, such as soyabean (China), groundnut (Latin America), and tropical forage grasses (Africa). Ironically, such countries have also called for restricted intellectual property rights (IPR) on resources in the Multilateral System. However, landraces are already considered to have limited present value for commercial purposes because they require the investment of a great deal of time and effort to find useful traits for integration into improved varieties and the private sector may even be less interested unless the reference to the patenting of isolated genes in the treaty is clarified. Specifically, article 12.3 (d) says that recipients of communal plant genetic resources shall not claim IPR on those resources or their genetic parts or components "in the form received from the Multilateral System." Victoria Henson-Apollonio, senior research officer for IPR at the CGIAR Central Advisory Service, thinks that "it will be difficult for the Governing Body to clarify the meaning of this article." But unless this happens, "it is impossible to say if the treaty benefits do overcome the risks," comments Bernard Le Buanec, secretary general of Assinsel, which represents more than 1000 breeding companies worldwide.

Indeed, this article was the reason that the US and Japan – both major CGIAR contributors – were the sole abstainers when the treaty was adopted, and several other developed countries remain concerned about the article.

The treaty will come into force when it has been ratified by 40 governments – something that could take at least two years. But FAO/IARC agreements are due for renewal this year, and the centers have been asked to sign new agreements with the FAO commission on plant genetic resources for food and agriculture, which will act as the treaty's Interim Committee until the Governing Body is formed.

Source: RIS based on www.checkbiotech.org, 6 February, 2002.

India bans GM soya oil imports

The recent approval of genetically-modified soyabean by China after several months of indecision is likely to add a sharp edge to the genetically modified soya oil controversy in India. As things stand, there is no domestic policy on genetically modified foods. The government's current position is that it will consider issues on a "case-by-case" basis. A decision on genetically modified soyabean or genetically modified soyabean oil, against this, would mean that the ground rules were being written by precedent for the import of other similar genetically modified foods.

The approval of genetically modified soyabean by China a fortnight ago will now open the gates for the import of one million tonnes of the transgenic seed from the US for large-scale farming in the country, according to a report in the *International Herald Tribune (IHT).* China's stand thus far against the farming of the crop was one of the arguments being used to buttress Indian stand against both the seed and the import of the edible oil from the seed. The agriculture ministry had first forwarded its complaint against the import of genetically modified soyabean oil to the environment ministry in August last. They had asked the latter to examine whether specific labelling of such oil was necessary since its effect on consumers in this geo-climatic region was untested. Simultaneously, letters were also sent to the health and the law ministries.

Firm replies on the genetically modified soyabean issue are still pending, but the agriculture ministry has now sewed up the lining at its end by putting in place restrictions on the import of genetically modified soyabean oil. Agriculture ministry had laid down rules that all imported soyabean oil should be genetically non-modified and labelled as such. The note from the core ministry on this has now been moved to the law ministry for clearance. Once cleared by all four relevant ministries, the rules which go into effect subsequently will ensure that all consignments of soyabean oil imported go through checks to ensure whether or not they are labelled as genetically non-modified as required.

Source: RIS based on *The Economic Times*, 24 March, 2002.

Missouri scientists finish genetic map of maize

The five-year research initiative, called the Maize Mapping Project, began in 1998 with an $11 million grant from the National Science Foundation. The project, which was presented to more than 400 scientists in March 2002 at a conference in Orlando, Fla., is expected to end next fall with completion of the integrated map. The integrated map will provide a baseline for future research that might lead to increased crop yields, fewer environmentally harmful pesticides and better food, said Edward Coe, project director and a geneticist at the U.S. Department of Agriculture. Creating the integrated map is like piecing together a jigsaw puzzle, said Karen Cone, assistant project director. The genetic map, she said, is like the edge pieces of the puzzle, which provide a framework for the inner pieces, or the physical map. When the outside and inside pieces are merged, scientists will see a complete picture of the maize genome, Cone said.

According to the project's grant application, some experts attribute 50 per cent of the recent increases in corn yield to genetic improvements. Still, Coe said, it remains unclear whether he'll continue doing the research and what benefits it might hold.

The NSF grant agreement requires that the project remain under close supervision by the foundation. Martha Cutter, assistant project supervisor at NSF, said the foundation is pleased with Coe's leadership. Despite the success, Cutter said that if MU researchers decide to continue the project, "the science would have to be state of the art" if they and their partners at Clemson University of Georgia are to secure more funding.

Source: RIS based on www.checkbiotech.org, 26 March, 2002.

Korea sets up biotechnology institute

The Korean government has identified biotechnology as one of the key technical tools to help solve the country's low competitiveness in the domestic and foreign markets. Aware of the significance of the "new biotechnology for future developments", Korea established the National Institute of Agricultural Biotechnology (NIAB) in 2002. Suhk Chul Suh, senior researcher of NIAB, said during the FAO-APAARI expert consultation on the status of biotechnology in agriculture in Asia and the Pacific, that the government believes that the institute can "contribute to the improvement of Korea's agro-biotechnology competitiveness in the world market".

The Food and Agriculture Organization and The Asia Pacific Association of Agricultural Research Institutions organized the three-day workshop which was held in Bangkok, Thailand. Korea has witnessed initial strides in its plant biotechnology programme. Both public and private companies are doing field trials of genetically modified crops. The Hungnong Seed Company is conducting field trials on virus resistant hot pepper. The Korea Ginseng and Tobacco Research Institute is carrying out field trials of virus resistant tobacco plants while the Rural Development Administration is working on a variety of transgenic plants including rice.

Source: RIS based on ISAAA, March 27, 2002.

US opposed to mandatory GM labelling

The Financial Express had sought response from the US Ambassador in India, Robert D Blackwill, on various issues pertaining to the US position on global trade in food and agriculture. Accordingly, keeping in wishes of the US Ambassador, a detailed questionnaire was sent, seeking opinion on issues of heavy direct and indirect subsidies given by the developed countries which have distorted global pricing, non-tariff barriers, technical barriers to trade and stringent sanitary and phytosanitary measures imposed by the developed nation against imports from the Third World as also the issue of labelling of GM foods.

Mr Blackwill, referred this to the US State Department in Washington, which, while explaining the US position on the proposed mandatory labelling of GM foods, said that the US has submitted comments to the Committee on Food Labelling (CCFL) on its proposed Draft Guidelines for the Labelling Genetically Modified (GM) Food and looks forward to discussing our position with Indian government officials in the weeks preceding the CCFL meeting in Halifax in May 2002. The US also tabled a Conference Room Document (CRD) in Ottawa in May 2002, "Practical Aspects of Labelling to Declare Method of Production for Bioengineered Foods" that raised a number of practical issues associated with method of production labelling of biotechnology food and food ingredients. This document was revised and considered at the CCFL meeting in May 2001. Our position and concerns on process-based labelling of biotechnology foods is reflected in our CCFL comments and in the CRD.

In reply to the question if mandatory labelling of GM foods is needed in the interest of 'right to information' and in the interest of food safety, it was mentioned that the US has consistently supported the highest standards for protecting the safety of food, both domestic and that entering international trade. US labelling regulations require labels for all foods, GM as well as others, only if there is a change in nutritional composition or if an added component is toxic or allergenic. These regulations are based on the quantifiable chemical characteristics of the food product and not on the way the product was made. US product-based labelling policy is objective, verifiable, and enforceable because the chemical properties of the food can be measured, confirmed and defended.

Further, the US does not support mandatory labelling of biotechnology foods to denote the method of production, be it production with, or without the assistance of biotechnology. The US believes it is immaterial whether a food product has been produced by purely natural means or with the assistance of biotechnology, as long as the food is free of harmful impurities. Moreover, the US is not aware of any information that foods developed through bioengineering differ as a class in quality, safety, or any other attribute from foods developed through conventional means. The US agrees that consumers have a right to obtain information about the food products they consume. However, we believe the consumers' desire for information on method of production can be best met through other means, including market-driven, voluntary labelling with regulatory oversight to ensure the communication of accurate, meaningful and verifiable information.

Source: RIS based on www.checkbiotech.org, 28 March, 2002.

Bt to boost cotton output

Environmentalists are crying foul. However, industry is enthusiastic over the clearance given to cultivation of Bacillus Thurengensis (BT) cotton and expect to get a major boost in the production from the current year's estimated 155 lakh bales.

Market sources said if new seeds are adopted on a large scale, India's annual production will easily cross 200 lakh bales of 170 kg each in the coming years. This is significant as demand is pegged to rise to 217 lakh bales by the end of 10th Five Year Plan.

"Depending on the quantum of shift in acreage to BT cotton, there will be a definite increase in cotton production in the next two years on account of higher yield, bollworm resistance and reduced expenditure on pesticides," chairman, Indian Cotton Mills Federation, Rajaram Jaipuria said.

There is a 30 per cent increase in yield expected form the new seeds which though insignificant when placed in the context of the miserably low productivity of an average 300 kg per hectare in India, will nevertheless boost production.

A one-third rise in yield from 300 kg to 400 kg per hectare carries little weight when compared to astronomically high yields of 800-1500 kg per hectare elsewhere.

However, more importantly the resistance to bollworm attack and lesser expenditure on pesticides will ensure better returns to the farmers.

As Bhartiya Kisan Union President Bhupinder Singh Mann said this will encourage farmers to get out of the wheat rice cycle and cultivate more of cotton. Jaipuria said proper cultivation, ginning and processing of BT Cotton, to prevent contamination, will scale down imports from the current 20 lakh bales

Source: RIS based on *The Economic Times*, 28 March, 2002.

BT cotton: sharing of DNA info mandatory

The genetic Engineering Approval Committee (GEAC) on Wednesday disclosed the conditions that will have to be met by companies wishing to produce genetically-modified (GM) BT cotton commercially. The GEAC also said that the next GM crop would be mustard. The conditions state companies manufacturing BT cotton would be required to inform the government, through the National Bureau of Plant Genetic Resources, about the DNA fingerprint of the GM seed. In other words, any company selling BT cotton seeds would have to tell the government the exact procedure of the gene modification it employs. "That way we are absolutely certain of the parental lines and testing procedure of the seeds. It would also help us identify transgenic traits of the BT cotton seeds, GEAC chairman A.M. Gokhale said.

Apart from DNA fingerprinting the companies would also have to monitor the susceptibility of BT cotton to the bollworm insect. They would also need to create awareness of the new cotton seed through an education programme and explain to dealers the procedure for farming the seeds. The Ministry of Rural Development is expected to assist in the awareness campaign by ropping in gram panchayats. GEAC has made it mandatory for farmers growing BT cotton to ring the crop with five rows of ordinary cotton. This means the farmer will not will be able to utilise at least 20 per cent of his land for BT cotton.

The committee has cited two reasons for this. First, the mixed crop would mean harmful insects would take a longer time to develop resistance to the BT cotton; and second, in case of cross-pollination, the gene crop cannot harm other crops.

Source: RIS based on *Hindustan Times*, 28 March, 2002.

Win in hunger war: rice genome mapped

An international team of scientists has unveiled the near complete genome sequence of the first crop plant, rice, which feeds half of the world's population. This breakthrough is being hailed in scientific circles as second in importance only to the sequencing of the human genome.

It will help scientists ensure food security for the hungry millions since they can now hope to breed with precision rice resistant to pests and which can survive salinity, drought and flooding.

The latest issue of *Science* carries two sets of the draft rice genome, the first prepared by Chinese scientists of the indica variety and the second by Swiss seed MNC Syngenta, of the japonica variety. Rice is the first to be mapped as it has the smallest known genome of all crops. In comparison, the corn genome, for example, is at least five times as large and that of wheat is 40 times as large.

The indica strain, sequenced by a team led by Dr Jun Yu of the Beijing Genomics Institute, is a major sub-species in China and the Asia-Pacific. Crossing the indica strain with another variety produces a hybrid with a 20-30 per cent higher yield per hectare.

A second team, led by Stephen Goff and colleagues at Syngenta, studied the japonica, found in more arid regions. The result may be rice with higher vitamin A content.

The rice sequence prepared by the 11 Chinese institutions is accessible at GenBank, the world's foremost repository on genetic sequences, but the mapping done by Syngenta, is accessible free for 41 of the world's poorest countries.

According to the authors of this paper, every day 24,000 people die from hunger-related causes and another 800 million go hungry. As the human population expands and farmlands shrink, food shortages are expected to become acute.

The genetic code behind rice "will expedite improvements in nutritional quality, crop yield and sustainable agriculture to meet the world's growing needs," said journal editor-in-chief Donald Keneddy.

Surprisingly, rice may be more complex than scientists ever guessed, densely packed with several small genes – perhaps more than the human genome. The rice genome may also provide a low-cost roadmap for investigating similar cereal crops such as maize, wheat and barley.

To sequence the rice genome, both teams used the "whole genome shot-gun method," previously used to sequence the human genome. Findings suggest that the indica genome draft covers 92 per cent of the whole rice genome.

In a second stage of research, the teams will produce a more detailed sequence, to be integrated with physical and genetic maps of the rice genome. It should reveal any gaps in the current draft and place all genes into functional categories.

As with indica, researchers said their draft is incomplete, but "provides a foundation for completing a high-accuracy sequence, enabling gene identification and facilitating physical and genetic mapping."

Another completely independent effort to map the rice genome is also underway, an effort in which India is also an equal partner. The sequence of the entire genome will be available by the year end.

Indian biotechnologists are fully geared to exploit information on the rice genome, says secretary of the Department of Biotechnology (DBT) Manju Sharma. About two years ago, India joined a 10-country international effort to map the rice genome. India is committed to sequence a part of chromosome 11 of the rice plant.

India is spending Rs 48 crore on the effort, and a 20-member team was put together at Delhi University and the Indian Agricultural Research Institute for the project.

"In India about 50 per cent of the precision mapping work has already been completed, with a third of the sequencing that India was to carry out already made public domain." The Indian team is now empowered to start mining the ice genome looking for genes of particular interest for the country. India decided to join the International Rice Genome Sequencing Project (IRGSP) led by Japan in 1997. The other members were the US, China, Taiwan, Korea, Thailand, France, Brazil and the UK.

India chose a particular part of the rice chromosome known to be a rich repository of disease-resistant genes for complete mapping. In return, the country would get access to the rest of the sequence collated by others.

The IRGSP has published 68 per cent of the rice genome in public databases. This 10-coutry effort hopes to put out a full sequence of the rice genome with an accuracy level of 1 mistake in 10,000 base pairs by the end of this year, which is a quantum jump over the quality of the genetic map put out by the Chinese and Syngenta scientists.

Source: RIS based on *The Indian Express*, 9 April, 2002.

India clears three Bt varieties

Indian agriculture has formally entered the transgenic era, with the Genetic Engineering Approval Committee giving the go-ahead for cultivation of Bt Cotton on Indian soil. The GEAC permitted seed company Mahyco to commercially release three of the four genetically modified hybrid cotton varieties developed by the company. Pesticide companies will lose business, green activists will predict doom, farmers will earn an extra Rs 10,000 per hectare and India will, according to experts, become the world's largest producer of cotton in a year's time. Bacillus thuringiensis, a common soil bacterium is a very effective biological pest control agent. Scientists have introduced the insectidal gene of Bt into the plant to produce transgenic Bt cotton, which produces the pest killing protein on its own.

The three-year approval for April 2002-March 2005, comes with several obligations on the company and the farmers to facilitate controlled operations, data collection and continuous monitoring.

Farmers cannot grow only Bt cotton – the Bt cotton crop must be surrounded by a sanitising band five rows deep of non-Bt cotton.

Source: RIS based on *The Economic Times*, 27 April, 2002

Report on International Conference on Biotechnology and Development*

A two-day international conference on "Biotechnology and Development: Challenges and Opportunities for Asian Region" was organized in New Delhi on February 26 and 27, 2002 by Research and Information System for the Non-Aligned and Other Developing Countries (RIS). On this occasion a new journal called *Asian Biotechnology and Development Review* was also launched. This new journal will come out thrice a year and shall be supported by UNESCO and Department of Biotechnology, Government of India.

Dr V. R. Panchamukhi, Director General, RIS in his welcome address reflected at past achievements of biotechnology programme at RIS that started in 1988 with a seminal volume titled *Biotechnology Revolution and the Third World: Challenges and Policy Options*. Subsequently RIS launched the journal *RIS Biotechnology and Development Review* in 1992 which now has been relaunched as *Asian Biotechnology and Development Review (ABDR)*.

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* Contributed by Dr. Sachin Chaturvedi, Research Associate, RIS and Managing Editor, *ABDR*.

Shri K.C. Pant, Deputy Chairman, Planning Commission and Chairman RIS inaugurated the conference. In his inaugural address Shri K.C. Pant hoped that biotechnology would offer new opportunities for global partnerships, especially between the countries which are rich in biological resources (which include genetic resources) but lack the expertise and investments needed to apply such resources through biotechnology and the countries that have developed the technological expertise to transform biological resources so that they serve the needs of sustainable development. He also hoped that biotechnology might assist in the conservation of those resources through, for example, *ex situ* techniques. He suggested that ABDR should act as a forum to deliberate on policy challenges before Asian countries in terms of its governance, financing and adoption. He further suggested that while doing so, adequate insights from experiences of other regions/countries might also be drawn upon, so as to make diffusion a cost effective process.

Dr. Manju Sharma, Secretary, Department of Biotechnology (DBT), Government of India congratulated RIS for launching of *ABDR*. She explained various programmes launched by DBT for integrating the biotechnology development with the overall economic development. She further suggested that the Asian countries should launch a programme to identify common developmental goals and technology strategies so as to make optimum utilisation of resources.

Dr. William G. Padolina, Deputy Director General, International Rice Research Institute, Manila, delivered the keynote address on "Biotechnology, Innovation and Development". He observed that in this era of expanding knowledge we are faced with the challenge of applying new tools towards the elimination of poverty and evolving a strategy for effective partnership in research and development. He further emphasized that effective delivery of new technologies to the resource-poor farmers should be ensured especially by the international agricultural research organizations and other research institutions. In this context, he suggested that public and private institutions must work together and explore new modes of institutional governance. He also felt that these institutional arrangements should be transparent, flexible, mutually beneficial and efficient. He hoped that research will proceed without delay so that the fruits of modern science and technology will be shared by all mankind in a timely way as more detailed knowledge on the genome is made public.

Dr Nagesh Kumar, Deputy Director General, RIS, took a stock of developments in biotechnology, especially in light of the projections made in RIS volume on biotechnology published in 1988 entitled, *Biotechnology Revolution and the Thrid World: Challenges and Policy Options*. A number of trends that had started emerging in the mid-1980s have become established norms in 1990s such as growing privatization, concentration and domination of biotechnology research by large MNCs, and vertical integration that have implications for research priorities and access of developing countries. However, other apprehensions such as a large scale substitution of commodity exports of developing countries have not come true.

Eminent experts from Bangladesh, Belgium, China, France, Japan, Korea, the Philippines, Singapore, and Thailand; senior officials from various Indian government departments; representatives from academic, business and industry circles of India and international organisations presented their theme papers and took part in the proceedings of the conference.

The programme of the conference included extensive discussions on a number of crucial issues like developmental potential and challenges of biotechnology for developing countries. Agriculture sector in Asian region was discussed extensively. Case studies on agricultural biotechnology in Malaysia and Thailand were also presented. Biotechnology for pharmaceuticals and health; trade, IPR and regulatory issues; convergence of technologies and implications for economic development; financing of biotechnology; and learning from experiences were the other major issues discussed during the two-day conference.

The conference also discussed an agenda for future research work programme in the field of biotechnology and decided to establish a network of research institutions working in this field. In this regard, all the participants showed extreme enthusiasm to initiate a forum for exchanging perceptions about biotechnology, exchange of information on simpler technologies available for transfer and their linkages with emerging intellectual property regimes. It was also suggested that *Asian Biotechnology and Development Review (ABDR)* should also periodically give a list of websites relevant for understanding developments in biotechnology in Asia.

Discussion: Bt Cotton in India

In India Bt Cotton has been recently cleared for commercialisation. This has attracted an intense debate. Here we have put together, with due permission, excerpts of two different perspectives based on The Economic Times *of April 2 and 3, 2002, for wider dissemination of issues and concerns related to genetically modified (GM) technology in general and Bt Cotton in particular.*

— *Managing Editor*

Point: *by Suman Sahai*[*]

Bt cotton is based on a technology that will work with reasonable success in many countries but it will not work in India. Its irrelevance to our small farmers is the crux of the resistance to its introduction here. Another reason why many have opposed Bt cotton (not GM technology) is the fact that it belongs to Monsanto. Monsanto has a record of prosecuting farmers for technology infringement and harassing them with lawsuits. Using their technology will have implications in the field of Intellectual Property Rights because their policies are in conflict with Indian law.

Bt cotton was developed for cold temperature countries like the US where pests are limited, — chiefly the bollworm, against which the Bt toxin works and pest load in fields is not high. Land holdings there are large, and subsidies are so huge that the risk taking capacity of farmers is substantial. Bt cotton is unlikely to work for more than a few years in India because it is fundamentally at odds with the agricultural and climatic conditions here. Insects are likely to develop resistance quite fast, making the variety useless in a few years. For the Bt technology to be successful, Monsanto stipulates that the farmer has to set aside about 20 per cent of his acreage for non-Bt cotton. This is essential so that the bollworm can feed partly on non-poisonous, normal cotton and remain susceptible to the Bt toxin.

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[*] The author is a geneticist and convenor of the NGO, Gene Campaign.

In the US with 10,000 to 30,000 acre holdings wasting 20 per cent of the acreage, even more if needed, is not an issue. Even then should everything go wrong, the 1 billion dollar a day agriculture subsidy of the OECD countries is more than adequate to bail out the American farmer.

In India, with its small land holdings, the economics of Bt cotton cannot work after setting aside 20 per cent as an insect refuge. There are many kinds of cotton pests in India apart from the bollworm. The use of pesticides will have to continue because spraying will be needed to kill these other pests. Pesticide use will also continue because as in all tropical countries, pest attack is far more intense and the number of insects per acre will be far higher than in colder countries. It is unlikely the Bt strategy alone will be effective in controlling the intense pest attacks common in the tropics. Monsanto, fully aware of this, recommends that farmers should count the number of insects in their fields and if these exceed a certain number, pesticide spraying should be done.

So what is the final take on Bt cotton for India? As the Genetic Engineering Approval Committee (GEAC) stated in its approval 'with conditions', Bt cotton is not recommended for small farmers. But wasn't the rhetoric of the scientific-administrative establishment these past few years replete with arguments that Bt cotton was crucially needed to provide a good cotton variety to small farmers to stop the tragedy of cotton suicides?

Now that the GEAC has had to admit what everyone knew from the start, that this Bt technology will not help the small farmers, the public needs to know who is responsible for pushing Monsanto's technology in this way. Which lobby is railroading India's GM policy? Given the record of pesticide abuse because of the failure to educate farmers, is it realistic to expect that the system of refuges will be implemented even by larger farmers?

The cotton problem in India has several causes. Mixtures of varieties are being sold to farmers in the name of standardised seed, resulting in uneven crops and low yields. Spurious and adulterated pesticides fail to control the pests, landing the farmer in deepening debt. There are problems with grading and pricing and ad hoc government policy when sudden imports can reduce the value of cotton crops. The problems facing cotton farmers have to be dealt at various levels if there is a genuine desire to solve them. With the introduction of Bt cotton, the government has sought to make Monsanto happy, not the cotton farmers in trouble.

Counter Point: *by Shubhrangshu Roy**

So the bio-fundamentalists are at it again, digging for worms in the cotton crop this time. For well over a decade now, we have been quite used to the protestations of bio-fundamentalists against genetic doctoring of God's good gifts. So their fulmination no longer surprises, even when, at times, their approach to modern science and commerce sounds plain stupid.

Ms Sahai claims that genetically modified cotton seeds are good for big farmers in the US, but bad for small farmers in India, because Monsanto will not allow them to steal its seeds. She also suspects that Monsanto's cotton seeds may not live up to their potential in hot and humid India. Unlike Ms Sahai, I am no geneticist. But common sense makes me respect the integrity of hundreds of small farmers who prefer suicide to lynching money lenders when faced with a crop failure. To encourage them to steal, actually amounts to berating the self-respect of our humble farmers.

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* The author is Senior Coordinating Editor with *The Economic Times*, Delhi.

I also wonder why Monsanto should spend money on marketing seeds that do not work in India. I would rather value its commercial judgement in developing a seed variety that earns huge profits here. And profit, to me, is not a dirty word.

For the record, Indians grow cotton over nine million hectares of land, accounting for the world's largest area under production.. But the yield, at 300 kg per hectare against a global average of 650 kg, is among the world's lowest. The fundamentalists would not tell us how productivity could get worse if the farmers grew pest-resistant cotton. For years now we have read reports about hundreds of cotton farmers in Andhra Pradesh, Maharashtra and Punjab ending their lives in desperation because they grew cotton that did not fetch them enough cash. Why did that happen? Because pests, called American bollworm, chewed up most of their crop. Now, and ironically, for the first time, an American company is offering a choice that will not only help our farmers survive the vagaries of nature, but also allow them to prosper. And the fundamentalists have problem with that.

That problem, I suspect, is not because the seed variety in question is genetically doctored, but because of who sells that seed. And in this case, the provider of quality seeds happens to be American with an eye to future profit. No doubt, Monsanto, rather its Indian partner, Mahyco of Maharashtra, will make money selling those seeds. But so will our farmers once they start growing a better crop than what they have been used to so far.

For close to five years now, farmers in Punjab, nearly 70 per cent of whom belong to small and marginal groups, have been growing bumper wheat from a single hybrid seed variety – 343 – on 85 to 87 per cent of the area under wheat cultivation. This seed variety has been developed by the state-run Punjab Agricultural University which has done pioneering research on several varieties of hybrid crop. Over the years, this laboratory-doctored, disease-resistant wheat has also become hugely popular with farmers in neighbouring Haryana, UP and Rajasthan. Now, as with all lab-to-land transfers, over dependence on 343 can create a potential problem. No one can predict when pests will mutate and chew up the entire wheat crop across Punjab's farmlands. Should that happen there will be no stopping the farmers from running to desperation. Yet, wonder why our bio-fundamentalists don't raise an alarm.

There are two reasons for this. One, the farmers are too comfortable growing the crop, and making money; they have no time for moral-hazard questions. Two, the seeds, having been developed at a state-run lab, have come to the farmers for almost free and are, therefore, not "stained" by profit incentive.

Bio Web

We give below a list of New Zealand related websites that could be of interest to readers.

http://www.agritech.org.nz
The main objective of New Zealand Agritech Inc is to increase sales and profit of member companies by improving exports. To achieve this, it works closely with Trade New Zealand, as an industry group, implementing co-operate marketing promotions in several markets.

http://www.biotech.org.nz
New Zealand Biotechnology Association

http://www.bizexport.co.nz
The self-help website for New Zealand exporters.

http://www.frst.govt.nz
The Foundation for Research, Science and Technology is the New Zealand Government's largest investor in innovation. It invests in research, science and technology to build wealth and well-being for New Zealand and does so through a number of schemes. These include a range of support schemes for business, grants for research, and scholarships.

http://www.gmcommission.govt.nz
Royal Commission on Genetic Modification website.

http://www.lifesciencenz.com
New Zealand Life Sciences Network.

http://www.maf.govt.nz/MAFnet/index.html
The New Zealand Ministry of Agriculture and Forestry (MAF) works to create an environment that enables private land-based interests and rural communities to conduct their business profitably and sustainably - to seize economic opportunities and advance environmental and social goals.

http://www.morst.govt.nz
MoRST (Ministry of Research, Science and Technology) is a New Zealand Government Department which develops research and innovation policies and manages the publicly funded part of the RS&T system on behalf of the Government. MoRST works at the high level of policies, strategies and statistics. It contracts other agencies such as the Foundation for Research, Science and Technology to manage the actual funding of research and innovation projects.

http://www.pacrimbiotechnology.com
The website for the 8th Pacific Rim Biotechnology Conference - to be held on Auckland during November 2002.

http://www.technz.co.nz
The Technology New Zealand Scheme, part of the Foundation for Research Science and Technology helps businesses develop and adopt new technology.

http://www.tradenz.govt.nz
New Zealand Trade Development Board

Bio-Stat

Biotechnology Statistics in New Zealand*

In the recent past, interest and investment in biotechnology has gone up considerably in New Zealand. A survey, commissioned by Ministry of Research, Science and Technology (MoRST), conducted by Statistics New Zealand, and published in 2001, shows that in New Zealand 93 enterprises use modern biotechnology and 57 of them are engaged in R&D. As Figure 1 shows, the food manufacturing, scientific research and industrial groupings under local government administration reported the largest number of enterprises involved in biotechnology. Their share was 19 per cent each followed by health services (14 per cent), non-food manufacturing (14 per cent), and tertiary education (5 per cent).

The use of modern biotechnology in New Zealand is at an evolving stage of development with many enterprises engaged in basic R&D. The product development stage is yet to be attained, even in those sectors where strong efforts in basic R&D have gone in. This gets amply reflected in the data related to intellectual property rights (IPRs). The survey shows that only a small proportion of biotechnology respondents made any patent application. In last five years, 33 enterprises made a total of 156 biotechnology patent applications. Out of them, 9 enterprises own 70 per cent of all biotechnology patent applications.

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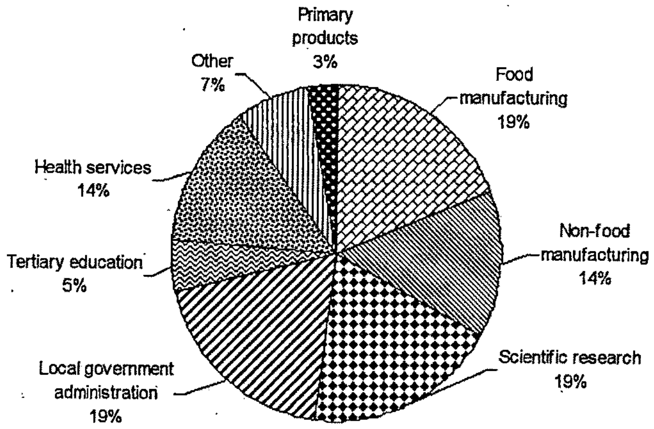
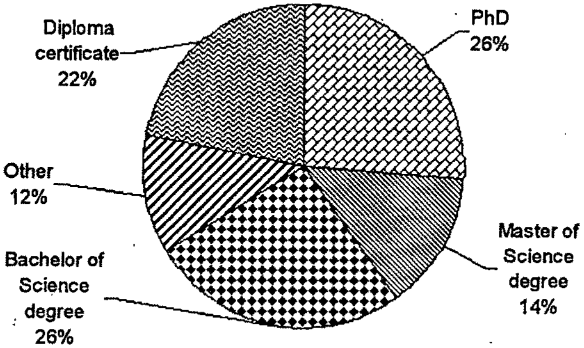
* Contributed by Dr. Sachin Chaturvedi, Research Associate, RIS and Managing Editor, *ABDR*.

Figure 1: Sectoral profile of New Zealand biotechnology companies



Source: Based on data from Statistics New Zealand (2001).

Figure 2: Distribution of human resources in private sector

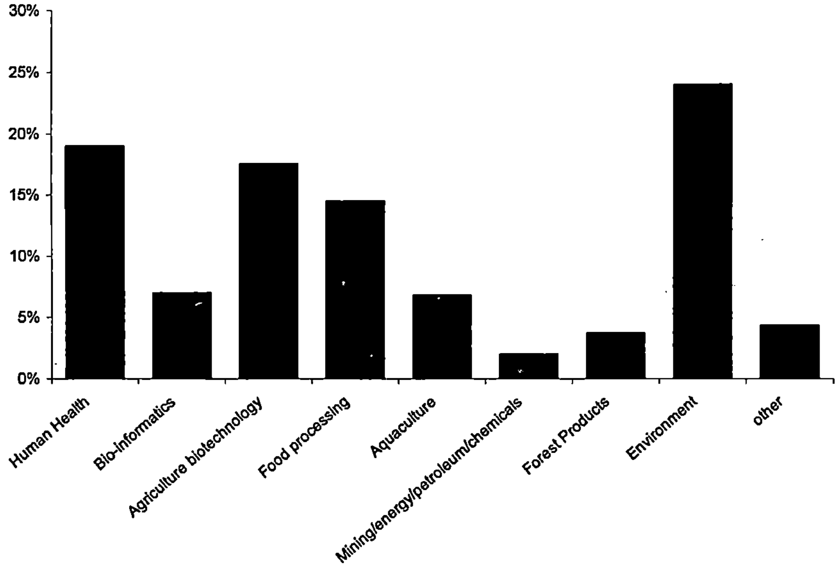


Source: Based on data from Statistics New Zealand (2001).

The employment in biotechnology activity represents 0.2 per cent of total employment generated in New Zealand in 1998-99. The survey reports that a total of 3057 (or 2727 full time equivalent) people were employed in the biotechnology related activities. As Figure 2 shows, out of them 26 per cent were graduates and 26 per cent had Ph.D degrees. The diploma certificate holders had a share of 22 per cent in the total employment in the private sector.

Figure 3 gives an idea about distribution of economic activities vis-a-vis usage of biotechnology products and services. It clearly shows that environment related activities have attracted largest number of enterprises, followed by the health sector. Food processing activity utilises biotechnology processes in areas such as testing to ensure that their output meets quality standards for domestic and foreign markets. Enterprises in the tertiary education and scientific research industrial groups are most active in human health and agricultural biotechnology activites.

Figure 3: Distribution of activities using biotechnology products and services



Source: Based on data from Statistics New Zealand (2001).

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ASIAN
BIOTECHNOLOGY AND DEVELOPMENT
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Vol. 5 No. 1 November 2002

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Research and Information System
for the Non-Aligned and
Other Developing Countries

Asian Biotechnology and Development Review

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The *Asian Biotechnology and Development Review (ABDR)* aims at generating wider awareness of the issues involved and emerging developments in the area of biotechnology. It hopes to serve as a forum of debate and dissemination of information on issues such as developmental potential of biotechnology, and the possibilities of South-South cooperation in this area.

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ASIAN
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Indian Biotechnology Developments in Public and Private Sectors - Status and Opportunities

S.R. Rao*

Reminiscence

The year 1982 was a landmark in the history of biotechnology in India. The Government of India, in order to promote biotechnology, relevant to the needs and priorities, constituted an agency, viz. the National Biotechnology Board (NBTB) under the Ministry of Science and Technology, as an apex co-ordinating body to identify prorities, coordinate, oversee and plan for required manpower, integrated industrial development and large scale use of biotechnology products and processes. A unique feature of this board is that all the existing S&T organizations and allied agencies have participated in formulating the objectives and organization of the structure of the board as well as made financial contribution for the core funding of the Board. In terms of identification of needs and priorities in biotechnology in India, the board had a unique international interaction through the formation of Scientific Advisory Committee (North America) [SAC(N)] in 1983.

Accordingly, various programmes for integrated manpower development and establishment of essential infrastructural facilities, realizing the need

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for capacity building through strengthening of existing laboratories, training of young scientists abroad, introducing course curriculum in biotechnology, etc. were initiated.

Establishment of Department of Biotechnology

Coinciding with the production of first transgenic farm animal and first approval of controlled experimental release of genetically engineered organism into the environment, in the year 1986 the NBTB was upgraded into a full fledged separate Department under the Ministry of Science and Technology, viz. Department of Biotechnology (DBT), in recognition of the need for having a focal point in the administrative structure of the Government of India for the purpose of planning, promotion and coordination of biotechnological programmes.

Present Scenario

Setting up of the separate Department of Biotechnology has given a new impetus to the development in the field of modern biology and biotechnology in India and has paid rich dividends.

Human Resource

Trained manpower and expertise in India belong to classical and modern biology/biotechnology. While in many developed countries it has become difficult to find young generation of classical biologists to supplement the inter-disciplinary modern biotechnology research, India has still adequate expertise in the fields like biochemistry, organic chemistry, taxonomy, pharmacology and traditional systems of medicine. Most of the present day modern biologists have long or short-term training in the laboratories of the USA and Europe. The programme of the government to award short - or long-term overseas fellowships, post-doctoral fellowships, etc. has resulted in the creation of trained manpower of more than 1000 scientists in a period less than 20 years. The post-graduate programmes in 47 universities and institutions train about 1000 students every year. Tailor-made industrial attachment and training programmes add value to the technical skills of these students so as to make them suitable for advanced R&D and production activities. India has also a vast network of 60 bioinformatic centres, with more than 10,000 users and 100 databases. Post-graduate and diploma courses at some of these centers train more than 100 students every year in the field of bioinformatics (refer map).

Biotech Infrastructure

Since 1986, concerted efforts have been made by the Government of India towards capacity building, both in terms of human resource and sophisticated infrastructure for R&D. As a result, India has world class facilities for DNA sequencing, protein engineering, bioprocessing, crystallography, molecular graphics and modelling, PL3 and PL4 level containment for work on dangerous pathogens, prescribed glass/animal houses for transgenic animal/plant research, repositories of micro-organisms important in agriculture, healthcare and industry, *ex-situ* and *in-situ* gene banks for crops and endangered medicinal and aromatic plants, medium and high throughput screening facilities for drugs and pharmaceuticals, biosensors, nuclear magnetic resonance machines, different mass spectrometers for various purposes, GM testing labs and recently micro arrays, automated DNA sequencing as well as robotic plasmid isolation equipment. Most of the facilities could be shared by both the public and private research laboratories at a cost comparable to that of developed countries. There are about 200 laboratories with state-of-the-art equipment and facilities for recombinant DNA research. Many private sector R&D facilities also have sophisticated equipment in most of these areas and some of them are paid-up service facilities for researchers. The biotechnology equipment market in India is about Rs.1500 million and is growing at the rate of 2 to 3 per cent and the demand is shifting from public research laboratories to the private sector.

International Cooperation

India has signed several bilateral agreements for implementing joint projects and human resource development programmes. The earliest among them has been the Indo-US collaboration known as "Vaccine Action

Programme" focused to develop jointly vaccines and diagnostics for communicable diseases, followed by the Indo-USSR programme on assisting manufacture of Oral Polio Vaccine (OPV) resulting in establishment of a public sector vaccines company, viz. Bharat Immunological and Biological Corporation Ltd. (BIBCOL) near New Delhi. The BIBCOL has supplied several million doses of OPV to national immunization programme. There are now several ongoing activities with both developed and developing countries, such as Germany, UK, Switzerland, Sweden, Japan, France, Israel, Sri Lanka, Myanmar, ASEAN countries and the countries from SAARC region. India also hosts one of the centers of International Center for Genetic Engineering and Biotechnology (ICGEB) at New Delhi for training and research needs of developing countries in particular.

The main objective of the biotechnology international collaboration is to assist in implementation of national programmes; acquisition of knowledge in areas of specialization not available within the country; share expertise and large scale facilities; participation in joint R&D programmes; and add to the economic wellbeing of the country through private sector participation in product and process development, technology transfer and communication.

Research

At a given time in a year, there are at least 1500 R&D projects implemented by all S&T agencies. The trend has shifted from individual investigator projects to multi-disciplinary and multi-institutional projects involving industry and scientists from even traditional sciences wherever needed. In India, in the context of biotechnology, the areas of core competence are bioprocess engineering; gene manipulation of microbes and animal cells; downstream processing and isolation methods; extraction and isolation of plant and animal products; recombinant DNA technology of plants and animals; stem cell biology; bioinformatics; proteomics and genomics; traditional and molecular marker assisted breeding of plants and animals; fabricating bio-reactors and processing equipment; human and animal health products; agriculture biotechnology; industrial and other biotechnology products, etc.

Institutional Framework

India is signatory to the WTO and the country is taking steps to enact the provisions of the WTO both in letter and spirit. More regulatory dictums within the framework of the international commitments made by India to the WTO and Convention on Biological Diversity (CBD) are in the offing. These include enactment of Plant Varieties and Farmers' Rights Bill and creation of Plant Quarantine Authority of India. The Plant Varieties and Farmers' Rights Bill will seek to protect currently unprotected plant varieties that are novel, distinct, uniform and stable, for a period of 15 year from the date of registration. The Biological Diversity Bill has been framed with the intention of protecting India's rich bio-diversity and associated knowledge against the use by foreign individuals and organizations without sharing the benefits that arise out of such use. The Indian Patent laws were significantly amended in 1999 as part of India's commitments to the WTO. Recently, India signed Budapest Treaty and established International Depository Authority at Microbial Type Culture Collections at Chandigarh. The Department of Biotechnology has also published Ethical Document entitled "Ethical Policies on Human Genome, Genetic Research and Services" prepared by the National Bioethics Committee. The document bans any research on human cloning and germline interventions by Indian investigators.

Regulatory Mechanisms for rDNA Products

The Indian rules and regulations as well as procedures for handling of the genetically modified organisms (GMOs) and rDNA products have been formulated under the Environment (Protection) Act (EPA) 1986. The rules enforced since 1993 cover manufacture, use/import/export and storage of hazardous micro-organisms, genetically engineered organisms or cells. However, a set of rDNA guidelines were issued in 1990 covering genetically engineered organisms, genetic transformation of plants and animals, mechanism of implementation of biosafety guidelines, containment facilities at lab level under three risk groups, etc. The guidelines have been reworked and issued as Revised Guidelines for Safety in Biotechnology matching with the newer aspects of technology. In order to provide special thrust to genetically engineered plants "Revised Guidelines for Research in Transgenic Plants and guidelines for Toxicity and Allergenicity for Evaluation of Transgenic Seeds, Plants and Plant Parts" came into force in 1998.

With coming into force of the above regulatory mechanisms so far 10 r-DNA drugs have been approved for marketing, four industrial units are manufacturing recombinant hepatitis vaccine, and locally and indigenously produced erythroprotein and G-csf are also available in the market. Several novel processes to produce r-DNA vaccines and drugs are in the advance stages of development. Under plants category, cotton with insect-resistant Bt gene was given approval for commercial release in March 2002. Following the regulatory procedures, at least 165 institutions are working in r-DNA research in India, which include 55 institutions engaged in transgenic plant research, both in public sector (42) and private sector (13). A large number of private institutions engaged in r-DNA therapeutics – about 25 out of 85 are doing basic research.

Regulatory policies in general are compliance friendly. However, the major criticism in this respect is that at present there are too many agencies involved in giving regulatory clearances. To address the concern of both public and private sector, efforts are under way to establish a single window regulatory mechanism or to put in place a structure which could promote speedy commercialization of recombinant products and processes. Over all, the system is relatively open and transparent yet precarious in its approach. In nutshell, there is enough expertise in technology and risk assessment of GM plants and therapeutics in terms of safety to environment as well as human and animal health. Keeping up with the recent trends/public perceptions on GM foods, appropriate measures and mechanisms are being evolved to label the same within the scope of CODEX alimentaries. GM detection and analytical food safety laboratories have been established to facilitate generation of scientific data. Similarly, containment facilities at the biosafety levels three and four are also available for both research and *in vivo* evaluations.

Technology Transfer

Since the early initiatives for biotechnology transfer of research leads, protocols and technologies to industry have been spearheaded by the Government S&T organizations, particularly the Department of Biotechnology. The process was accelerated with establishment of Biotechnology Consortium India Limited (BCIL), in 1990, to act as an agency for forging effective linkages between research, financial and industrial institutions and the policy making framework at the government level. So far more than 60 technologies and research leads from the Government funded R&D projects have been transferred to Indian industries for scale up, validation and commercialization. Some of these products such as leprosy vaccine, HIV and hepatitis diagnostic kits, natural streptokinase, veterinary diagnostics, etc. are already in the market and some others are in pipeline. With a view to encourage the institutions to file patent applications on their innovations, and to motivate them to transfer their technologies for commercialisation, and facilitate them to reward their inventors, some more instructions were issued during 2002 for institutions receiving funds for research projects from the Ministry of Science and Technology.

The institutions have been permitted to retain the benefits and earnings arising out of the IPR. The IPR generated through joint research by institution(s) and industrial concern(s) through joint efforts can be owned jointly by them as may be mutually agreed to by them through a written agreement. The institution and industrial concern may transfer the technology to a third party for commercialisation on exclusive/non-exclusive basis. The institution shall set apart not less than 25 per cent of such earnings for crediting into a fund called Patent Facilitating Fund. This Fund shall be utilised by the institution for updating the innovations, for filing new patent applications, protecting their rights against infringements, for creating awareness and building competency on IPR and related issues. The funding agency shall have a royalty-free licence for the use of the intellectual property for the purposes of the Government of India.

The general practice in many cases is to transfer technology through bidding by interested companies. Depending upon the stage of technology, market potential, and the cost effectiveness, transfer agreements typically contain clauses on payment of upfront lump sum (Rs 0.2 to Rs 20 million) royalty on sale proceeds (1 to 5 per cent) and exclusive or non-exclusive rights for a periods of 3-7 years.

Reforms in Science Funding and Management

India is among the few countries where S&T funding agencies are completely managed by qualified, scientists with specialization in the field being dealt by them. From time to time, several measures have been taken to institute expert-based priority setting process, peer review mechanisms, reducing project processing periods from submission to sanction, simple accounting systems for monitoring physical and financial progress, etc. Further, in most of the cases, all stakeholders are involved in decision-making.

Recently, national awards for biotechnology research and career development, special awards for women scientists, biotechnology product and process and commercialization have also been instituted by the government to recognize the innovation and excellence of scientists both in public and private sectors. However, there are some nagging problems at laboratory/institution/individual scientist level related to tedious and time consuming procedures for utilization of sanctioned funds, placing orders for equipment/chemicals, placement of research scholars, collaborating with laboratories abroad, visit to foreign countries for training or participation in international conferences. The problems are similar to all other disciplines and not specific to biotechnology. However, biotechnology being knowledge-intensive, tool and technique based, delay in implementation procedures often discourage investigators to take up innovative projects requiring timely decisions. Further, dual or erratic/ higher pricing policy of consumables and equipment by many foreign suppliers and their Indian vendors makes research in advanced areas unaffordable even though manpower is relatively cheaper. Appropriate measures, therefore, are needed to alleviate the problems faced by scientists in dealing with these matters so as to accelerate the pace of research and development and create work atmosphere.

Investments

Investment in Indian biotechnology began with the early initiatives of government and setting up of a separate department of biotechnology. Five year plans are made for such investment by the department for promoting biotechnology R&D, human resource development, establishment of biotechnology facilities, product and processes development and other activities. Since the establishment of the Department during the financial year 1985-1986 to March 2002, an investment of Rs.12.95 billion has been made. Fifty per cent of this investment has been made in the last five years and the same is increasing approximately by 30 per cent. In the early years most of this investment was made for human resource development and establishment of infrastructure. Since, 1997-98, the annual allocations for R&D are almost more than 60 per cent. Medical and agriculture research receive maximum funds.

Besides the Development of Biotechnology, other government S&T organizations agencies such as Indian Council for Agricultural Research (ICAR), Council of Scientific and Industrial Research (CSIR), Indian Council of Medical Research (ICMR), University Grants Commission (UGC) and Department of Science and Technology (DST), also support R&D programmes in biotechnology. Since in all of these organizations there is no separate data pertaining to biotechnology, it is difficult to provide the actual figures of investments made by these agencies. However, normally the contribution or sharing of cost in most of the projects is about 30 per cent, and, therefore, it can be presumed that the contribution by all these organizations would be around Rs.4.00 billion since 1985 till date.

Private Sector

Private sector investment has also been picking up since 1997 and became particularly visible after the announcement of the draft human genome sequence in the year 2000. There are no authentic statistics on the investment in the private sectors. This is because the definition of biotechnology and its indicators vary for different estimations. An Indian directory prepared by Biotechnology Consortium India Ltd. (BCIL) in

January 2001 includes biotechnology activities of about 176 companies in private sector whose products range from those in agriculture, environment and healthcare. On the other hand, estimates have also been made that about 800 companies are operating in various sectors of biotechnology, based on the definition that biotechnology includes basic industry such as food processing and highly sophisticated recombinant products. Employing the same definition one estimate says that 10 per cent (80) of these companies are operating in modern biotechnology sectors while according to another conservative estimate there are only 20 companies engaged in sophisticated biotechnology business. Similarly, it is also estimated that the industry employs 10 to 20,000 people and generates roughly a revenue of US$ 500 million annually. The Indian share of the biotechnology market was estimated at US$ 800 million in 1999 and has risen approximately to US$ 2.5 billion this year. Consumtion of biotechnology products is expected to touch the figure of Rs.14.6 billion.

Notwithstanding these figures by various estimations, it can be concluded that India's burgeoning biotechnology sector is an oasis of rich picking for investors as the government leads the drive to develop the industry. Building a biotechnology industry is a part of knowledge economy strategy of the government. A growing number of high quality Indian biotechnology investment opportunities exist for both early and late stage investors. Some of the major investors include, Connect Capital, ING Barings, Dresdner Kleinwort Benson, London and Warburg Pincus are evaluating Indian biotechnology investment opportunities. And that is not all; a London Stock Exchange-listed biotechnology company (with a market capital of US $125 million) is keen to ally with an Indian biotechnology firm, possibly via a merger. It has also been predicted recently by both Indian and US Business leaders that US stock market listings by Indian technology companies could explode to 100 or more new issues within the next five years.

Venture Capital Funding

With the increased role of established private sector as well as start-up companies investing in biotechnology, several financial institutions/

agencies, both in public and private sectors, have launched venture capital funding mechanism. The Ministry of Science & Technology created these opportunities through the establishment of Technology Development Board (TDB) in 1992 for providing financial assistance to industrial concerns and other agencies attempting development and commercialization of indigenous technology or adopting imported technology for wider domestic application.

The board has been particularly helpful in promoting several new start-up companies. Since its formation, the board has signed 100 agreements with commercial enterprises/agencies with a total projects cost of Rs 15.00 billion and there is a commitment of Rs.3.58 billion financial assistance to areas of health and medicine, engineering and electronics, chemicals and lubricants, agriculture and biotechnology, waste utilization, etc. Companies such as M/s. Shanta Biotechnology and M/s. Bharat Biotechnology, producing recombinant hepatitis vaccine, and M/s ABL biotechnology in marine biotechnology, are some known and successful beneficiaries.

Venture capital (VC) funding in India for biotechnology projects picked up with success stories of the technology development board (TDB). Six or seven prominent VC firms, including ICICI (Industrial Credit and Investment Corporation of India), Morgan Stanley, and Small Industries Development Bank of India (SIDBI) are active. The venture capital is mostly available to companies whose product and market are clearly identified and research leads are already available for commercialization. During 2001, the biotechnology venture capital committed by different financial agencies other than the Technology Development Board (TDB) amounts to a total of Rs.2.80 billion during the year 2001.

Foreign Direct Investments (FDI)

FDI is seen as a means to support domestic investment for achieving higher level of economic development through technology upgradation, access to global managerial skills and practices, optimum utilization of human and natural resources, making Indian industry internationally competitive, opening up of export markets and providing linkages and access to international quality goods and services. Due to several steps taken by the Government of India, in terms of encouraging foreign investments in general, the approved Foreign Direct Investment (FDI) in biotechnology sector during 1999-2002 amounts to a total of Rs.1478 million for 26 cases. This amount is very meager compared to total FDI of all sectors which amounts to several million thousands of US dollars. This is due to inadequate awareness on the part of the foreign investors about the latest policy of the Government of India for the development of industries in all sectors including biotechnology (refer Box).

Incentives for investment in biotechnology industry and R&D

- 100 per cent foreign equity investment is possible in almost all sectors.
- 100 per cent foreign equity investment is automatic in drugs and pharmaceuticals sector, and over 74 per cent is on case by case basis.
- Fast Tract Clearance route for FDI.
- Depreciation allowance on plant and machinery set-up, based on indigenous technology.
- Customs duty exemption on goods imported for use in Government funded R&D projects.
- Customs and Excise duty exemption to recognized Scientific and Industrial Research Organisations (SIROs).
- 125 per cent weighed tax deduction on R&D Expenditure.
- Three-year excise duty waiver on patented products.
- 100 per cent rebate on own R&D expenditure.
- 125 per cent rebate if research is contracted in public funded R&D institutions.
- Joint R&D projects are provided with special fiscal benefits.

For details: www. techno-preneur.net
www. dbtindia.org

Biotechnology Activities in the States

With several major advances in biotechnology taking place in the last few years, it is natural that state governments wish to take part in the ongoing biotechnology revolution and benefit from the same.

States of Karnataka, Andhra Pradesh, Maharashtra, Uttar Pradesh, Madhya Pradesh, Gujarat, Himachal Pradesh, Kerala and Orissa have shown keen interest in the concept of developing biotechnology parks. Karnataka and Himachal Pradesh have set up separate Departments of Biotechnology at the state level. Others have set up Biotechnology Boards/Task Forces, respectively to make detailed plans. Tamil Nadu, Karnataka, Kelara and Andhra Pradesh have already announced their biotechnology policies.

State governments are also setting up biotechnology development funds of their own and earmarking significant amounts to invest in the companies located within their respective boundaries. Andhra Pradesh Industrial Development Corporation (APIDC), Kerala Venture Capital Fund (KVCF) and Karnataka State Industrial Infrastructure Development Corporation (KSIIDC) are some of the examples of the venture capital commitments amounting from Rs 100 to 500 million. Among them, State Government of Karnataka has been quite forward with total investment of Rs 13.00 billion during 1999-2002, while Andhra pradesh signed MOUs with biotechnology firms such as Proximare, Bioserve, Genetics and Sun Microsystems in San Francisco for putting in place concrete programme of research collaboration. In general, state governments have also announced incentives related to exemption of sale tax, concessions for land allotment, water and electricity and labour laws. The basic objective of these State Government initiatives is to promote bio-industry preferably based on local resources. Local people are also expected to benefit from the resultant employment generation.

Conclusion

The initiatives taken by the Government of India in the field of accelerating the growth of biotechnology sector since last two decades have paid rich dividends. India has developed competence in selected biotechnology areas and come out with policies which provide the entrepreneurs an edge over other countries to set up viable and competitive biotechnology industry in certain areas. With its large resource pool of modern/molecular biologists, statisticians and software programmers, India seems well placed to capture most of the biotechnology market. Many Indian companies have introduced products of original research through technology transfer from R&D institutions of India in the field of vaccines, diagnostics and reagents. Some Indian have also teamed up with foreign collaborators for sourcing technologies and are experimenting new products produced with the help of foreign technologies with a view to introducing them into the Indian market within the framework of Indian laws. This situation is satisfactory to begin with, but there is tremendous scope to come up with innovative products that would be original and would have a cutting edge impact in the global context. Fresh investment of about US $1.00 billion in India could hold the potential of providing turnover of US$1.50 to 2.00 billion during the next 5 to 7 years, that could contribute to import substitution, augmentation of local production and introduction of some new products for global marketing in the areas such as diagnostics, vaccines therapeutics, pharmacogenomics, bioinformatics, agriculture biotechnology, industrial biotechnology, and also provide inputs to the industry (hardware suppliers - instrumentation and chemicals), marine biotechnology, biodiversity and bioprospecting and environment-focused biotechnology. India is expected to emerge as a strong player in both manufacturing and consumption market of biotechnology products in the coming years.

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The Current and Future Outlook of Agricultural Biotechnology in Malaysia

Hassan Mat Daud*

Introduction

During the past few years, biotechnology has emerged as a powerful technology that has a big potential for a number of economic sectors, including agriculture. A number of basic human needs such as food, cloth, medicines and a cleaner environment have been fulfilled through biotechnological means. New developments in genomics (namely the human genome project and other genome projects in a number of organisms including important crops such as rice), bioinformatics and proteomics have opened new frontiers in biotechnology R&D. The convergence of these new technology platforms with the powerful information technology now provides a greater understanding of the biology of plants, animals, humans, and micro-organisms at the molecular level, enabling us to develop better strategies and approaches to deal with current and future challenges.

The last millennium witnessed the shift of the Malaysian economy from its reliance on the raw and unprocessed products to manufactured goods. However, agriculture continues to play an important role in the overall economic growth of the country. During that period, the Malaysian agricultural sector was left with two major challenges. The first major challenges is in the realm of addressing national food security, i.e. to produce sufficient amount of food to meet the national needs. The country is not producing sufficient amount of food for the populace. A drastic change in the exchange rate of the ringgit during the economic crisis of the late 1990s reinforced the above need as imported food items tend to be more costly. Of the total RM32 billion in the year 2000 budget, about RM10.52 billion was allocated for the imported food bill. The second major challenge relates to creating wealth for the nation through production of value-added food and food products, which are more competitive in the open market, and to supporting the manufacturing sector through production of sufficient amount of raw material. The far-sighted vision on the role of the agricultural sector in supporting economic growth of the country requires crucial injection of new high technology to transform this sector to be more productive especially in meeting the two challenges stated above. The agricultural sector must prepare itself from now not only to produce sufficient amount of food, but it should also produce high quality products that can compete with the imported produce during the current era of globalization. The National Agricultural Policy outlined a transformation route for the agricultural sector to be more productive, efficient, competitive and more commercialized.

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The last millennium also left us with the technology that will enable us to address the above challenges. The discovery of DNA and rapid development in the science and technology of molecular biology during the last millenium has ushered us into a new era – the biotechnology era. During that period, biotechnology has proved its ability to transform a sector – such as the agriculture sector – while generating new industries to support economic growth in the developed world. Genes, the basic biological unit of life, that programme a character of plants, animal and micro-organisms, are amenable to modification, manipulation and transfer across species to bring about desired outcomes. Biotechnology has been recognized as one of the new high technologies that will bring about desired changes in the agricultural sector.

Institutional Development

Historically agricultural biotechnology development in Malaysia can be divided into three phases: the period of establishment (prior to 1995), development phase (1995-2000) and advancement phase (beyond 2001): Prior to 1995, initial establishment of agricultural biotechnology R&D took place in a number of research institutions such as MARDI, PORIM (now MPOB), and RRIM (now MRB) as well as at various universities such as UPM, UKM, UM and USM. The development at the institutions includes establishment of basic infrastructures such as molecular and cellular biology labs with necessary equipment and set-up, and establishment of basic expertise to undertake biotechnology R&D. The National Working Group on Biotechnology was set up under the Ministry of Science, Technology and Environment (MOSTE) to oversee and coordinate biotechnology activities in the country.

Subsequent to the successful establishment of basic infrastructures and technical competencies, many developments have taken place during the period of the 7th Malaysia Plan (1996-2000). Implementation of the national initiative and agenda on biotechnology was further enhanced with the establishment of the National Biotechnology Directorate (BIOTEK) under MOSTE. The mission of BIOTEK is to spearhead the development of biotechnology in Malaysia through research and related activities directed at commercializing biotechnology, and to establish Malaysia as a leading centre for biotechnology industry. Under BIOTEK, a mechanism called Biotechnology Cooperative Centers (BCC) was established to assist the Directorate in coordinating the National Programme in Biotechnology; developing a network among participating institutions (universities, research institutions and industries); and pursuing leading edge research and accelerating diffusion of knowledge to the industry. Seven BCCs have been established to cover primary biotechnology research areas, viz. plant-, animal-, food-, environmental/industrial, medical-biotechnology, molecular biology and bio-pharmacy. Besides the BCC system, another mechanism called the Contact Group Programme was also established by BIOTEK to facilitate direct communication and linkage with participating institutions of the public and the private sectors.

Recently, the Malaysian Government has endorsed a mega plan to develop biotechnology in the country under the BioValley Malaysia. The plan is based on the cluster concept where groups of specialized companies that support each other to create a "center of excellence". Companies within the cluster can take advantage of the presence of physical infrastructures, facilities, human resource, entrepreneurship and sharing of ideas to enable them to compete at a global level.

R&D

During the 7th Malaysia Plan (1996-2000), four R&D programmes were implemented under BIOTEK under the coordinatorship of the BCCs. They were:

I) Top-down research projects: National research projects directed by the National Scientific Research and Development Council for implementation by multi-institutions involved in biotechnology. A top-down project on rice genetic engineering for tungro virus resistance, for example, has led to the development of a transgenic rice that is resistant to one of the virus (RTSV) that is causing the disease. The project has also paved the way for other improvement of rice.

II) Experimental developmental projects: Up-scaling projects that need to be developed after laboratory-scale R&D before they are commercialized. Public research institutions and universities are encouraged to forge partnerships with one or more companies in the private sector for undertaking these projects.

III) Partnership programme: The programme involves partnership of a group of institutions in Malaysia with a prominent international center of excellence in relevant field of biotechnology. The Malaysia-MIT Biotechnology Partnership Programme is an example of a partnership programme that has entered its third year of implementation.

IV) Bilateral programme: A supportive programme linking existing research interest/projects in Malaysia with a similar counterpart in another country. The support is mainly for exchange of information, training and transfer of technology.

Another programme that supports biotechnology R&D in Malaysia is the Intensified Research Priority Area (IRPA) under MOSTE. Although this programme is not under BIOTEK, advice and guidance of the Directorate are always required in implementing the programme on biotechnology. Issues that have been given priority in developing biotechnology projects are: Food security of the country; reducing the import bill on food and feed; and for wealth creation. Among the projects that have been implemented are: genetic engineering of papaya for virus resistance and improved shelf life of fruits; gene transfer system for oil palm; genetic engineering of rubber; and genetic engineering of orchids for improved shelf life of flowers.

Consumer Acceptance, Transfer of Technology and Globalization

As biotechnology is becoming more and more a commercial reality, its impact on consumers as well as producers is well recognized. The subject of GMOs is relatively new to Malaysian consumers. In general, the public is not well informed in the subject matter. As past surveys have shown, there is significantly more support among those who said they had heard a lot about GMOs than those who heard little about them. The National Biotechnology Directorate is stepping up its effort to implement public awareness programmes on biotechnology during the 8th Malaysia Plan (2001-2005). The programmes include arranging lectures at both a nationwide public forums as well as in schools; preparing and distributing phamplets about biotechnology; and promoting understanding on biotechnology through mass media.

With globalization coming our way, two new issues have to be addressed: transfer of technology and the threat of globalization. Bulk of biotechnological research is done in the private sector, the relevant information and data are not publicly available, and most of the relevant technologies and materials are not in the public domain. With such a situation, a developing nation like Malaysia viewed technology transfer as a critical agenda since the nation is still far behind in expertise, infrastructures, and financial support. Developed nations must facilitate technology transfer to developing counterparts in order to face challenges thrown up by globalization. It is also the challenge to a country like Malaysia to acquire expertise and capability in biotechnology as it moves forward in the era of globalization.

Future Strategies

Two strategies have been adopted for future development of biotechnology in Malaysia. First relates to strengthening the existing programmes/projects by focusing on key research fields and key platform technologies. BIOTEK will continue to support capacity building such as infrastructure, human resource development (HRD) and management. The role of BCC programme will be enhanced through grouping for common technological needs under three main R&D areas, viz. agro-forestry, healthcare and energy/environmental management. Technical competencies will be developed under a separate programme for technological development on in three identified areas, viz. genomics, bioprocessing and DNA diagnostics. The second strategy relates to developing new innovative projects which can ensure that research is translated into commercial products for global market place, thus making Malaysia more competitive in key biotechnology opportunity area. This will contribute to the national economy programme. This strategy is implemented through the establishment of the National Institute of Biotechnology Development Programme.

Conclusion

As the world moves into the era of globalization, where economy becomes borderless, enhanced efficiency, competitiveness, productivity and quality will take precedence in determining our success in the global arena. Malaysia is positioning herself to face the in-coming challenges being brought by globalization. Technology, such as biotechnology, will be a strong driving force energizing the shift into a knowledge-based economy. Intensive application of high technology and competency building will enhance this transformation process to position the country where it can look forward to emerge as a stronger economy.

The country has no doubt about the benefits emanating from biotechnology, which was claimed by many as the technology of the 21st century for national development. It has been recognized as a major growth industry worldwide. Advances in biotechnology have spearheaded novel growth and development opportunities in a diverse range of industries such as pharmaceuticals, food processing, plant and animal production, and environmental management. The strategic plan for biotechnology developed by BIOTEK for the future should lead to a more dynamic and competitive biotechnology industry in Malaysia, capable of facing challenges of the next millennium and helping to contribute towards development of nation and move forward to realize the goal envisaged in achieving our Vision 2020.

Agricultural Biotechnology in Thailand

Nares Damrongchai*

Introduction

Thailand is known to be one of the developing countries that is also world's largest net food exporter. Yet staying at the forefront of the world agricultural market has never been an easy task. Realizing the stiff and increasing competition in the world market, a master plan for the country's agricultural development, approved by the cabinet in early 1998, aims at research and development to raise production, cut costs by using new agricultural biotechnology, and bring product quality and processing up to international requirements. The plan also encourages farmers to use less chemical fertilizer while promoting natural alternatives and organic production, improving management of natural resources and environment.

Though most of the economic sectors in Thailand registered negative growth rates after the economic crisis in 1997, the agriculture sector has expanded by about 2.8 per cent in 1998. The tables given below show the top ten agricultural products' in recent years production, earnings and exports. (Tables 1-3).

Although the country's transition to new agriculture, or agicultural biotechnology, has been hitherto taking place at a rather low pace, the

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Table 1: Production of Major Agricultural Products in 1999/00, 2000/01

Item	Planted area (million rais)		Yield (million tonnes)	
	1999/00	2000/01	1999/00	2000/01
Rice	64.49	65.64	24.17	25.6
Corn	7.80	7.87	4.28	4.39
Tapioca	7.40	Na	18.26	17.8
Rubber	9.77	na	2.37	2.44
Sugar cane	5.90	5.42	53.49	49.07
Coffee	0.44	na	0.8	na
Soybean	1.45	1.46	0.32	0.32
Oil plam	1.30	na	3.25	na
Tomato	0.06	na	0.2	na

Source: Thailand, Office of Agricultural Economics.

Table 2: Earnings from Agriculture Sector in 1999/00 and 2000/01

(million baht)

Item	1999/00	2000/01
Rice	87,609	91,210
Sugar cane	23,858	24,093
Corn	18,387	16,665
Coffee	2,659	2,524
Rubber	48,119	na
Tapioca	12,010	na
Soybean	2,753	2,991
Oil plam	5,405	na
Tomato	2,294	na

Source: Thailand, Office of Agricultural Economics.

Table 3: Thailand's Top Ten Agricultural Products in 2000 and 2001

(Million baht)

Item	2000	2001
Rice	65,504	70,074
Rubber	60,741	58,700
Fresh and frozen shrimp	61,551	56,563
Fresh, chilled or frozen of poultry	16,756	25,592
Tapioca products	13,887	17,970
Fresh fruits	5,215	5,716
Fresh vegetables	1,610	2,452
Orchids	1,231	1,494
Seed	1,121	1,433
Coffee	1,691	1,172

Source: Thai customs department.

transition is soon to increase its speed, thanks to relatively good infrastructure.

The good research infrastructure in agriculture in Thailand can be traced back far into history. The present good human resource situation owes to the establishment first of Mae Jo Institute of Agricultural Technology (now Mae Jo University) in Chiangmai, followed by the establishment of Kasetsart (Agricultural Science) University and other institutes of higher learning with agriculture faculties.

However, research in these academic institutes, as well as in government agencies like the Department of Agriculture, has been mostly of adaptive nature, viz. improvement of existing or imported varieties and their products through conventional breeding and agronomic means.

Changes in research tradition have been gradually occurring, both through new manpower trained abroad, and through programmes and institutes with overseas origin, such as the Rockefeller Foundation programme at Kasetsart University. Although most of the agriculture research to date still revolves around conventional plant and animal breeding, agronomy, animal husbandry, soil science, etc., a significant amount of research is now devoted to the application of new biotechnology, cellular and molecular biology to agricultural problems. These changes are taking place not only in universities, but are also occuring gradually in government research institutes, such as the Department of Agriculture, with linkage to international agencies like the International Rice Research Institute.

Tissue Culture and Seed Technology

Among the subfields of agriculture, those on which biotechnology has had the greatest impact, are probably tissue culture and seed technologies. This is probably because there was already a good infrastructure for these technologies even before the advent of new biotechnology. The two technologies provide the end-users – gardeners and farmers in substantial numbers – with crucial inputs: plantlets and new seed varieties.

Tissue culture techniques were introduced to Thai orchid growers in the 1970s, and the former rapidly proved to be superior to traditional seed propagation techniques in reproducing orchid plants. As the production site for many transnational seed companies, Thailand today is one of the most important seed producing and exporting countries in the world. Some of these companies have also invested in R&D activities. However, these R&D, are mostly of the adaptive type, as the transnational and joint venture companies rely primarily on their parent companies abroad for fundamental seed technology research. The lack of an appropriate seed variety protection law appears to have been one of the reasons for the reluctance of the private sector to invest in basic seed technology R&D. The Plant Variety Protection Law, promulgated recently, will help in promoting such R&D in Thailand in the near future. Despite lack of basic R&D, Thai researchers in tissue culture and seed technologies have been relatively productive, and are well linked to the users, although they produce relatively few written scientific publications.

Plant Biotechnology and Genetic Engineering

The work focus on plant biotechnology and genetic engineering have been focused on two main areas, plant transformation and DNA fingerprinting.

The first area should lead to the production of transgenic plants with superior properties including the resistance to diseases, insect pests and abiotic stress.

Research activities in this field were pioneered by the Plant Genetic Engineering Unit (PGEU), the satellite laboratory of the National Center for Genetic Engineering and Biotechnology (BIOTEC) at Kasetsart University, Kamphaengsaen, Nakorn Pathom. Transgenic tomato plant carrying the coat protein gene of tomato yellow leaf curl virus (TYLCV) was first developed to control the serious virus disease of tomato. The same approach was taken to develop transgenic papaya and pepper for the resistance to papaya ringspot virus (PRSV) and chilli vein-banding mottle virus (CVbMV), respectively. Another key biotic stress of crop production is the loss due to insect pests. Sri Somrong 60, a Thai cotton variety, was successfully transformed with cryIA(b) gene expressing a *Bt* toxin from *Bacillus thuringiensis*. Transgenic cotton plants will be used for controlling the cotton bollworm *Helicoverpa armigera*. For abiotic stress resistance, attempts has been made to transform Khaw Dawk Mali 105 – an aromatic Thai rice with 1-purroline-5-carboxylate synthase gene (P5C5) for salt and drought tolerance using particle bombardment technique.

Most of the transgenic plants developed in Thailand are now being tested under greenhouse conditions and field testings in accordance with the biosafety suidelines. More issues about biosafety and the debate over genetically modified organisms (GMOs) will be discusse later in this paper.

The rice biotechnology programme was launched by the National Center for Genetic Engineering and Biotechnology (NCGEB) in collaboration with the Rockefeller Foundation. Researchers from universities, Department of Agriculture and other agencies were given support to work on such areas as development of molecular markers for rice breeding, development of salt-tolerant rice varieties, wide hybridization between cultivated and wild rice species, development of transgenic rice varieties, mechanism of pathogenesis in rice bacterial and viral diseases, and identification of aromatic components of jasmine rice, etc.

The locations of important genes have been identified. Identification of molecular markers linked to aromatic gene in rice utilizing random amplified polymorphic deoxyrobonucleic acid (RAPD) technology was developed and genetic locus of aromatic trait in Thai rice was identified. Bulked line analysis method was developed for identification of the restriction fragment length polymorphism (RFLP) markers associated with a target gene. With the method, a fertility-restoring gene was identified and mapped. Work on quantitative trait loci (QTL) mapping has discovered a tightly-linked markers of flood-induced elongation and leaf senescence to recover from flooding. This finding may provide breeders to design an efficient marker-assisted selection scheme and marker-based gene cloning. Genes controling intermediate amylose content in rice were also mapped.

In 1999 BIOTEC has provided 60 million bahts funding to start the Thailand Rice Genome Project. BIOTEC on behalf of Thailand has joined the International Collaboration for Sequencing the Rice Genome (ICSRG) led by Japan, by sequencing 1 Mb annually of chromosome 9 for the next five years. Chromosome 9 was selected based on previous extensive works on the fine genetic and physical maps surrounding the submergence tolerance QTL mentioned above, prospecting for gene richness on a relatively small chromosome. Joining ICSRG enabled Thai scientists to directly access the rest of the genome sequence made available by the other collaborating members. In parallel, gene discovery from wild rice germplasm will be undertaken to efficiently utilize the genome sequence data. The project will bring Thailand to international scientific arena, incorporate state of the art technology and finally improve the competitive edge of Thailand in the international rice market.

Cassava and Starch Technology

Of 16 million tonnes of cassava roots in 1998, approximately 70 per cent, are used in the production of pellets and chips while the remaining are mostly used in the production of flour and starch. Production shortage in 1997-1998 prompted the Thai Tapioca Development Institute (TTDI) and Kasetsart University to develop new strain of higher yield to gear towards making Thailand a production base for the tapioca industry. Kasetsart 50 is the newly developed strain with an average yield of 26.4 tonnes of roots per hectare and a starch content of 26.7 per cent as compared with the 13.75 tonnes per hectare and 18 per cent starch content of the best strain available before.

Tapioca starch industry is one of the largest industries of Thailand. In 1998, tapioca starch was worth 5 billion bahts. About 40 per cent of starch were used domestically for the production of modified starch, sweetener and monosodium glutamate while the remaining 60 per cent were mostly exported. Efficient production process, low production cost, and the development of value-added products are vital to the starch industry and the farming sectors of totally 1.3 million hectares planting area. On this basis, the programme on starch and cassava products was established to provide support and funding for research and development. The programme is funded jointly by BIOTEC and TTDI to carry out research and development in three core activities. The short-term project is to improve the processing efficiency of starch production, particularly to minimize water and energy consumption. Reduction of water usage not only can lower water cost, but also lessen the need for wastewater treatment. A benchmarking on water usage is a priority for the Thai starch industry. Besides, attempts have been made for protein enrichment using various micro-organisms such as *Aspergillus* and *Rhizopus*, but the economic feasibility is still in doubt and further technological development is needed.

Basic studies of cassava starch structure and physicochemical properties are now being undertaken at the Cassava and Starch Technology Unit, a specialized BIOTEC laboratory established in 1995 at Kasetsart University. The unit is well equipped; hence regular service and training on instrumental analysis of starch properties have been provided to the private sector and governmental agencies.

Biocontrol Agents and Biofertilizers

Related to the development in plants resistant to diseases and pests, transgenic or otherwise, is the effort to find biocontrol agents, which can either be used as such, or the genes which can be incorporated into the transgenic plants. Over the past two decades, the developmental work on biocontrol and biofertilizers in Thailand has continued to receive active support from BIOTEC and Thailand Research Fund (TRF).

Recent development study on biological control of root-knot nematodes by soil fungus, mass production and application of *Trichoderma* for biocontrol of *Sclerotium rolfsii Sacc., Ketomium* for the control of soil fungi such as *Phytophthora*, field application of *Hirsutella thomsonii* for microbial control of agricultural mites, local production of nuclear polyhedrosis virus (NPV) to control cotton bollworm (*Heliothis sp.*) and other insects. Two companies are now producing *Trichoderma* and *Ketomium* commercially. BIOTEC and Department of Agriculture have combined strength to set up a pilot scale production facilities for the production of NPV, *B. thuringiensis* and *B. sphericus.* NPV is widely used to control Spodoptera moth in the production of grapes.

For the control of vegetable pests such as *Plutella* and *Spodoptera*, locally produced *B. thuringiensis* and *B. sphericus* have gained popularity over the last few years. The bacillus production has taken up the production capacities of pilot plants at Mahidol University and King Mongkut University of Technology Thonburi (KMUTT). It is anticipated that commercial production (100 tonnes per year) will begin within a couple of years. In order to improve the efficacy, a group of researchers at Mahidol University, with support from BIOTEC, is working on transferring the chitinase gene into *B. thuringiensis israelensis.* There has also been much development in the use of neem for the control of diamond back moth and the leafminer which have developed high resistance to conventional insecticides.

The use of biofertilizers can lessen dependence on chemical fertilizer, resulting in cost saving as well as reducing deleterious environmental and human effects. The Department of Agriculture pioneered the production of *Rhizobium* for use with leguminous plants. Appropriate strains were selected for this purpose, and commercial scale production has been carried out. Blue-green algae appropriate as biofertilizer was also selected and produced at the commercial scale by Thailand Institute of Scientific and Technological Research (TISTR).

Animal Biotechnology

Recent development of animal biotechnology in Thailand has mainly revolved around import and adaptation of new, high-yielding strains of farm animals such as cows and pigs. The major problems encountered for imported species are development of resistance to infectious diseases, adaptation to hot and other conditions of the tropics, finding of optimal growth conditions and development of appropriate feeds.

Foot and mouth disease has increasingly become an important endemic disease threatening not only Thailand, but the whole of Southeast Asia and beyond, creating an important obstacle for development of export industry for animal products.

Much research in animal science, accomplished in Kasetsart and Mahidol Universities, has been devoted to embryo transfer technology. A Mahidol University team has, for example, developed embryo transfer technology for cattle including the ability to recover immature oocytes from valuable donor cows, intracytoplasmic fertilization with spermatozoa from genetically superior but infertile bulls, and sexing and cryopreservation of preimplantation embryos. These techniques are being applied to conserve endangered animal species such as the Thai elephant.

More recently, cows had been cloned by a team at Chulalongkorn University (CU) together with Suranaree University of Technology (SUT) using embryo transfer technique, same of which gave birth to "Dolly the sheep". Since then animal cloning has become a fast developing area of animal research in Thailand. Application of this technology is expected in the field of animal breeding and production as well as conservation of endangered species.

Over the past decade, Thailand has been a major producer of prawns, especially tiger prawns, for exports. This has been the result of expansion of land, first in the shoreline areas and later in the inland areas as well, used for intensive culture of prawns, often with little environmental consideration. It is, therefore, necessary to develop sustainable systems for prawn aquaculture. One main problem is the development of the parent stocks, so that they need not be harvested from the sea. Other important problems include production of disease-free broodstock, disease-resistant varieties and early diagnosis of viral and other diseases.

Since the beginning of the 1990s Thailand has led the world in the export of farmed shrimp and the industry has been worth approximately US$ 2 billion in yearly export earnings for the country. These earnings are especially important because they are based very largely on inputs of local origin. The shrimp farming industry has not developed without production and environmental difficulties but both government and industry are unified in efforts to reach the goal of a sustainable aquaculture with minimal negative impact on the environment. BIOTEC has been particularly active in supporting research and in stimulating cooperation to solve production and environmental problems in the shrimp industry.

An important milestone was achieved in 1996 when a five-year effort of BIOTEC culminated with the establishment of the Shrimp Culture Research and Development Company Limited (SCRD), a government-industry consortium dedicated to the development of sustainable shrimp aquaculture. Currently, the most important programme of SCRD involves the domestication and genetic improvement of shrimp stocks. Up to now, SCRD has successfully reared Black Tiger prawn (*P. monodon*) in captivity in southern Thailand for five years. The shrimp, which have been screened to exclude both white spot syndrome virus (WSSV) and yellow head virus (YHV), are now in their fifth generation in captivity and have been selected for their growth rate to normal market size of 25-30g. They have shown excellent performance under culture and the reproductive performance continues to improve and in some cases has approached that of wild spawners. SCRD now plans to expand its operations on a more commercial basis to produce nauplii, postlarvae and broodstock for sale to Thai farmers and hatcheries. Its plan is to construct a single Nucleus Breeding Center (NBC) and one Broodstock Multiplication Center (BMC), and to work with several other partners to develop additional BMCs to meet market demands.

The BIOTEC is also supporting advanced studies on DNA characterization and DNA tagging of the shrimp stocks for the genetic improvement part of the SCRD programme. These studies are providing the tools that will be important for rapid genetic improvement strategies.

Other important milestones in the BIOTEC programme have been the development of DNA probes for the rapid detection of major shrimp pathogens. These probes are essential for the development and monitoring of certified shrimp broodstock and fry. They detect for diseases that present no health risk to shrimp consumers, but the probes are critical tools for the prevention of shrimp diseases that sometimes cause disastrous production losses. Indeed, BIOTEC's support for research on the development of a DNA probe for WSSV, one of these pathogens, has yielded a benefit that can be valued at approximately US$1 billion per year for Thailand since 1996. This example serves to illustrate clearly how research can be vitally but unpredictably important to the Thai economy.

Work on WSSV in Thailand began unpredictably in 1994 as the result of a chance infection of laboratory reared shrimps. These shrimps were under observation for a different major shrimp viral pathogen, the yellow head virus, originally discovered in Thailand in 1992. In retrospect, we now know that WSSV originated in China in 1993 and gradually spread from there to the rest of Asia in succeeding years. In China, it resulted in a drop of shrimp production from approximately 155,000 metric tonnes in 1992 to 35,000 metric tonnes (77 per cent decrease) by 1994. When the chance discovery of WSSV occurred in the laboratory in Thailand, the virus had not yet caused any known farm losses. In the meantime, work was done to investigate the nature of the virus and to develop diagnostic probes for it. A major discovery with the probe was that shrimp fry used to stock shrimp ponds could be the source of the virus. By the time the virus began to affect farms in Thailand, a good amount of research information had already been accumulated and this helped considerably in mitigating its negative impacts. The research allowed for the development of effective prevention programmes which included the use of DNA technology to screen stocking fry so that WSSV positive batches could be rejected. The benefit of this research can be roughly estimated from the prevention of farm loss of no less than $1 million per year.

BIOTEC is now moving to the next step from producing WSSV- and YHV-free stocking fry, to fund more research in other shrimp diseases. It will also promote research into the breeding of virus-resistant shrimp (the so-called 'super shrimp') in the near future.

Safety Issues of Genetically Modified Plant and the GM Debate

Thailand is one of the first countries in the region to adopt its national biosafety guidelines as early as 1992 both for laboratory work and for field testings and planned release. The guidelines were initiated by BIOTEC and the completion was largely the efforts of individual scientists and officials of relevant governmental agencies.

Subsequently in 1993 the National Biosafety Committee (NBC) was established with BIOTEC serving as the coordinating body and secretariat. Later on many Institutional Biosafety Committees (IBCs) were established at various major research and academic institutes throughout Thailand. Currently, there are 14 IBCs including one private enterprise laboratory overseeing all the research activities involved in the use of genetically modified organisms.

As the technical support to various government authorities in the decision making related to the safety of genetically modified organisms, NBC has established three specialized biosafety subcommittees, focussed on plants, micro-organisms and food. These subcommittees are functioning as technical advisory groups and risk assessment bodies. They work in coordination with relevant government agencies in the GMO approval process.

The first request of introduction and field testing of genetically modified organism in Thailand was the Flavr Savr tomato. The Department of Agriculture, Ministry of Agriculture and Cooperatives acted with technical recommendation from NBC, granted permission for the field trial of Flavr Savr tomato in 1994. The purpose of the field trial was to produce seeds destined for export only. The request for field trial of genetically modified cotton with toxin gene from *Bacillus thuringenesis* was made in 1995. Field trial of this *Bt* cotton started in March of 1996. But until today, permission for the commercial release of *Bt* cotton is still pending.

In October 1999, with the controversy concerning the safety of GMOs escalating around the globe particularly in the European Union countries, Thailand's Committee for International Economic Policy issued a policy statement affecting the commercialization of genetically modified plants. The statement prohibited any commercial import or release into the market of any GM plant seed. Field trials, however, were still allowed under the jurisdiction of Department of Agriculture. This was actually in accordance with the Plant Quarantine Act. Legally, Thailand's 1964 Plant Quarantine Act (amended in 1994 and 1999) restricts importation of 40 different varieties of transgenic plants unless it is permitted case by case and only for research purpose. However, for practical purpose, the above Committee has agreed to exempt the import restriction of transgenic soybean and maize grains (not seeds) based on the fact that risk assessment has been performed on these commercial crops and they are regularly traded in the world market.

Nevertheless, recognizing the urgent need for Thailand's own risk assessment capability in GM food, the NBC's subcommittee on Food Safety drafted a guideline for safety assessment of genetically modified foods in 1999. It is now being considered by the Thai's FDA for use as a national guideline. The guidelines followed the internationally accepted concept of substantial equivalence. The first transgenic food plant product, that is seeking approval for use in food industry, is the Bt cottonseed oil. The decision is still pending by the Thai's FDA. Using this guideline, Roundup Ready soybean and both Bt and Round up Ready maize varieties from Monsanto have been evaluated as safe for human consumption.

Table 3: Thailand's GMOs Chronology

Date	Events
1983	Inauguration of Thailand's National Center for Genetic Engineering and Biotechnology (NCGEB, now BIOTEC).
1985	Establishment of BIOTEC's Plant Genetic Engineering Unit (PGEU) in Nakhornpathom, Thailand.
1986	BIOTEC commissioned a status report on the prospects of biotechnology in agriculture and stated the need for the country's biosafety regulatory system.
1990	A feasibility study on biosafety by BIOTEC.
1990	Biosafety Subcommittee was established under BIOTEC.
April 1992	BIOTEC appointed an ad hoc subcommittee to draft Thailand's first biosafety guidelines.
June 1992	Complete draft of biosafety guidelines (for laboratory and for field test).
January 1993	National Biosafety Committee (NBC) established with BIOTEC as secretariat, followed by establishment of Institutional Biosafety Committees (IBCs) at various research institutes.
1993	First application for importing transgenic plant for field test on seed production (Calgene's Flavr Savr tomato).
1994	A list of 40 prohibited transgenic plants added to the 1964 Plant Quarantine Act.
1994	Flavr Savr tomato granted permission for field test.
1995	Application of Monsanto's *Bt* cotton.
1995	Establishment of DNA Fingerprinting Unit, BIOTEC in Nakhorn Pathom, Thailand.
March 1996	*Bt* cotton field test experiment started in northeastern Thailand.
1997	Establishment of Plant Biosafety Subcommittee under NBC.
1998	Establishment of Food Biosafety Subcommittee under NBC.
1998	Establishment of Microbial Biosafety Subcommittee under NBC.
1999	Trade dispute between Thailand and some EU countries over detention of tuna in oil from Thailand. Other trade dispute cases follow suit.
1999	Subcommittee for Policy on Trade of Biotechnology Products set up under the Committee for International Economic Policy
1999	Amendment of the 1964 Plant Quarantine Act to strengthen regulation of transgenic plants.

Table 3 continued

Table 3 continued

Date	Events
September 1999	A report "Status of GMOs in Thailand" published by BIOTEC.
September 1999	First public hearing on GMOs organized by Department of Agriculture (DOA) held in Bangkok.
October 1999	First survey in Bangkok by BIOTEC on public awareness and attitude towards GMOs.
December 1999	Inauguration of Thailand Biodiversity Center (TBC) as the potential national focal point for the Cartagena Protocol on Biosafety (Thailand has not yet signed the protocol). NBC's secretariat (including subcommittees) moved to TBC.
2000	Establishment of DNA Technology Laboratory (former part of DNA Fingerprinting Unit), with a mandate to detect GMOs on service basis, among other tasks.
2000	Establishment of two separate GMOs detection laboratories in Department of Agriculture and Department of Medical Science.
2000	Thailand Food and Drug Administration (FDA) commissioned a work group to consider labeling method for GM foods.
March 2000	Ministry of Agriculture and Cooperatives' declaration on import prohibition of 40 transgenic plants (revised) with exceptions for grains of GM corn and soy bean.
April 2000	Trade dispute between Thailand and Kuwait/Saudi Arabia over tuna in oil (suspected to be made from GM soya bean).
October 2000	A National Subcommittee on Biosafety Policy proposed to the National Committee on Conservation and Utilization of Biodiversity (NCCUB), with TBC as secretariat office.
January 2001	Trade dispute between Thailand and Egypt over tuna in oil reached its peak. Both party agreed to sign MOU.
February 2001	A draft of GMOs policy approved by the Subcommittee for Policy on Trade of Biotechnology Products.
March 2001	BIOTEC starts a series of consulatation meeting with stakeholders on GMOs issue.
April 2001	A controversial resolution by the cabinet to hault Ministry of Agriculture's large scale field trials according to a request from a pressure group, until a biosafety law is finished.
August 2001	BIOTEC conclude consultation series.

Currently, the products being assessed by the subcommittee includes genetically engineered papaya for viral resistance developed domestically and separately by BIOTEC, Department of Agriculture and Mahidol University.

The Department of Agriculture is soon to announce 37 additional GM varieties to be prohibited by Plant Quarantine Act. The Thai Food and Drug Administraion (FDA), on the other hand, is moving to label GM food. Meanwhile the Ministry of Agriculture is making a petition for the cabinet to reconsider its decision in haulting the field trials back in April 2001, claiming that such move is inhibiting the progress in scientific research and development of the country (Table 3).

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Biotechnology in Bangladesh

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Introduction

Biotechnology in its simplest connotations may be defined as a technology based on biological systems – plants, animals and microbes or parts of it (cell, tissue, gene or DNA) to derive the best goods and services for the benefit of human being. Although the practice of biotechnology principles was very old, as in the case of fermentation processes like making of alcohol, yogurt, preparation of cheese, bread etc, the term 'biotechnology' itself got its due place after the principles of recombinant DNA technology or genetic engineering came into picture. And now when we talk of biotechnology we usually mean the technology derived primarily through the use of 'recombinant DNA'. But recombinant DNA technology in principle although sounds to be simple (taking gene from one organism and putting into another) but in practice it is quite complex, tenacious, costly and challenging.

It is for this reason that for the use of modern biotechnology, although started long back during late 1970s, many countries, both the developed

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and developing ones, could not enter into the arena because of lack of adequate fund, manpower, infrastructures and the political will as well. The countries of the Asian region although have a good agricultural land, good climate for agricultural production and also good climate and manpower for industry, in reality most are poor. Over population, coupled with high degree of illiteracy, have kept many countries of this once prosperous region below proverty level. Therefore, to overcome the situation in resonably early period of time cultivation of modern science like 'biotechnology' is highly essential. The opportunities of utilization of biotechnology for mitigating the sufferings of teeming millions of the region are enormous but the challenges for doing so are also quite hard. It is heartening to note that Research and Information System (RIS) for the Non-Aligned and other Developing Countries took the initiatives for discussing this highly important issue in a Workshop, held in New Delhi, on February, 26-27, 2002. In the following paper the opportunities and challenges of biotechnology and development in the region vis-a-vis Bangladesh will be discussed and suggestions to overcome the bottlenecks will be put forward for due consideration.

Bangladesh Economy

In the region of Asia, Bangladesh is comparatively a very small country with only 55,598 sq. miles of land (1,43,999 sq km) in between primarily big neighbouring country – India bordering almost two-third of the territory. The other immediate neighbours of Bangladesh are Burma to the east and south and small stretch of Nepal to the north. But, within this small area of land Bangladesh has nearly 130 million people to live in. The population density is nearly 2000 per sq miles – one of the highest in the world. Most of the people live in the villages – rural: 85 per cent and Urban: 15 per cent. The population growth rate at present is 2.3 per cent per annum which is also quite high in comparison with any developed countries.

Bangladesh basically is an agricultural country and agriculture is the major industry upon which 80 per cent people depend. Fertile alluvial soil of the Ganges-Meghna-Brahmaputra (GMB) delta, coupled with high rainfall (average 100 cm) and easy cultivation, has made this small riverine country coveting for many outside settlers from time immemorial which is the root cause of thick population. Rice is the major food crop, which is cultivated round the year and jute had been the major cash crop till recently. The per capita income is at present nearly US $ 400 which has increased to this level during the last 5-7 years from below US$ 300.

Beside agriculture the other major resource at present is the natural gas which is estimated to be between 25-40 trillion cubic feet.

Universities and Research Organisations of Bangladesh

Bangladesh has at present five General Universities, two Engineering Universities, two Agricultural Universities and a Medical University. In addition, the government has very recently taken due initiatives for starting with 12 science Universities. Besides, there are nearly 30 private Universities in Bangladesh, mostly located in and around Dhaka. But, the curriculum of these private universities is mostly limited to computer science and business administration only. The number of government. universities is very less compared to enrolment pressure and usually more than 50 candidates appear for one seat in a government university. The total capacity of all the government universities will be less than 100,000. The following important research organisations are now functioning in Bangladesh.

- Bangladesh Atomic Energy Commission (BAEC)
- Bangladesh Council of Scientific and Industrial Research (BCSIR)
- Bangladesh Rice Research Institute (BRRI)
- Bangladesh Agricultural Research Institute (BARI)
- Bangladesh Jute Research Institute (BJRI)
- Bangladesh Tea Research Institute (BTRI)
- Sugarcane Research and Training Institute (SRTI)
- Bangladesh Institute of Nuclear Agriculture (BINA)
- Sericulture Research Institute (SRI)
- Bangladesh Livestock Research Institute (BLRI)
- Bangladesh Fisheries Research Institute (BFRI)

Most of these institutes have been functioning for more than 30 years and the total number of scientists working in different institutes will be nearly 3000.

Research work in Bangladesh till recently was mostly carried out by individual scientists in a fragmented manner. Previously there was no separate research budget for this purpose. At present separate R&D budget is given by the government for this carrying out research work. In addition, a special grant of Tk 120 million is provided by the Ministry of Science and Technology every year for R&D in physical, biological and engineering sciences. However, the annual expenditure per scientist in a year will not exceed US$ 500.

Present Status of Biotechnology in Bangladesh

The programme on plant biotechnology in Bangladesh was initiated in late 1970s in the Department of Botany, Dhaka University with tissue culture of jute. Thereafter within a span of 10-12 years tissue culture research laboratories have developed in different universities and R&D organisations, like Dhaka University, Rajshahi University, Chittagong University, Jahangirnagar University, Khulna University, Bangladesh Rice Research Institute, Bangladesh Jute Research Institute, Bangladesh Agricultural Research Institute, Bangladesh Council of Scientific and Industrial Research, Bangladesh Atomic Energy Commission, Bangladesh Institute of Nuclear Agriculture, Bangladesh Forest Research Institute and Institute of Post Graduate Studies in Agriculture. A few NGOs like DEBTECH and PROSHIKA are also working on plant tissue culture. As a result of intensive work on plant tissue culture protocols on plant regeneration and micro-propagation have been developed on different crops, forest plants ornamental and fruit trees as well as vegetables. These *in vitro* regeneration protocols are now awaiting for commercial exploitation. It is expected that with the establishment of private entrepreneurs commercial utilization and expansion of tissue culture techniques will gradually find its due place in Bangladesh.

Animal and Insect Biotechnology and Aquaculture

In animal biotechnology Bangladesh Live-stock Research Institute (BLRI) and Bangladesh Agricultural University (BAU) have already taken modern biotechnology programmes. These include embryo transfer technology, multiple ovulation embryo transfer and artificial insemination programme. But, the programme of animal gene transfer through genetic engineering technique has yet to be started. However, livestock biotechnology produced 11 types of veterinary biologics for the treatment of infectious diseases in livestock and poultry, vaccines for foot and mouth disease and rinder pest. Biotechnology in fisheries induces spawing in carp, pabda, catfish, koi and others. With this technology 50,000 kg of different fish species can now be produced annually.

Sericulture Research Institute, Rajshahi has been working for a long time for the improvement of sericulture production in Bangladesh. During recent past genetic engineering techniques have also been adopted for the purpose. At the Bangladesh Atomic Energy Commission low dose of gamma radiation to the silkworm has been employed for the enhanced production of silk. Significant progress has been achieved on sterile insect technique (SIT) by utilizing gamma radiation. Besides, hormonal and pheromonal control of insects and also the integrated pest management (IPM) programme are now being adopted for insect management. Isolation and characterization of *Bacillus thuringensis* strains for the control of Lepidopteran insects has been initiated at the university of Dhaka.

Industrial Biotechnology

In the field of industrial biotechnology Bangladesh is yet to make real breakthroughs. Modern biotechnological programmes involving gene transfer technology have yet to be started in real earnestness. Whatever has been possible is through classical/old biotechnology methods. However, the results are quite encouraging and a good number of projects are in advanced stage which can be taken up for commercialization. Some of these research programmes are:

- Bioconversion and bioprocessing of agricultural and agro-industrial residues for feed, fuel and chemical.
- Genetic improvement of industrial micro-organisms like citric acid production by *Aspergillus niger* through gamma radiation.(has reached commercial stage)
- Mass scale production of *Spirulina* (has reached commercial stage).
- Production of biofertilizer (has reached commercial stage).
- Production of amylase and gluco-amylase for scarification of low cost starch.
- Production of microbial biomass protein and single cell protein.
- Production of tannery enzymes.
- Production of alcohol from agroindustrial residues – a few distilleries in the country are already utilizing >50,000 MT of molasses for the production of ethyl alcohol.
- Preservation of fruits, vegetables and spices by radiation and bioprocessing.
- Bioenrichment of cereal food by microbial fermentation.

Bioenergy and Environmental Biotechnology

A significant achievement has been made in the field of 'BIOGAS' production from animal excreta (cowdung) and agricultural residues. The Institute of Fuel Research and Development (IFRD) has been working since long in this field. As a result of research findings and its subsequent development in collaboration with Department of Energy (DOE) at present more than 10,000 biogas plant have been installed in rural areas. An extended programme to set up about 100,000 biogas plants throughout the country has also been taken up by the government which is now under implementation.

In case of environmental biotechnology Bangladesh is yet to start its programme by utilizing modern biotechnological techniques. Whatever has been possible is through conventional methods. But, because of excessive population pressure and overall industrial activity, environmental pollution is gradually increasing day by day and is causing a real threat to human health and ecological balance. Industrial effluents, municipal garbage and sewerage are discharged with minimum or no treatment at all into the surface water, causing water pollution. The Department of Environment (DOE) of the Government of Bangladesh is doing some routine work only. Among the limited activities Bangladesh Atomic Energy Commission (BAEC) has installed advanced facilities to analyse harmful agrochemical residues at a very low concentration. Microbial technology could be a useful tool to minimize the solid waste and effluents causing pollution. What is needed is a broadbased 'bioremediation' programme involving modern biotechnological approach including the development of microbes capable of degrading Xenobiotics and recalcitrant pollutants.

Bangladesh is yet to start, in real earnestness the techniques of genetic engineering for the improvement of plant, animal, and industrial micro-organisms and also to combat environmental pollution problems, etc. At present only a limited number of laboratories are working to introduce and utilize the gene transfer technology for the improvement of crops like rice, jute and also for obtaining better strains of industrial microbes. Research and development of animal genetic engineering is particularly very limited at present. The list given below tells about what research work is being carried out at present in different universities and research institutes:

- Agrobacterium mediated genetic transformation of jute: being carried out at the Institute of Food and Radiation Biology, AERE, BAEC, Dhaka and Bangladesh Jute Research Institute.
- Genetic transformation of pulses for fungus resistance: initiated at the Department of Botany, DhakaUniversity (DU).
- Genetic transformation of rice and jute for salinity tolerance and fungus resistance: being carried out at the Deparment of Biochemistry, DU.
- Use of DNA probes for the diagnosis of diseases: being initiated at the Institute of Nuclear Medicine, BAEC, Dhaka.
- Development of food, fibre and energy through recombinant DNA technology: being carried out at the Department of Zoology, Rajshahi University (RU).
- DNA finger printing of rice and jute at the Department of Biochemistry, DU.

The National Institute of Biotechnology

The concept of a National Institute of Biotechnology in Bangladesh was developed as early as 1984 and a Project Proposal was submitted to the government by the same year. Thereafter, the matter was subjected to different examinations and evaluation by the government for several years. Subsequently in a meeting in 1993 of the National Council for Science and Technology (NCST) it was decided that an Institute of Biotechnology would be established in Bangladesh. Accordingly, a Project Proposal was submitted to the Planning Commission. The Planning Commission advised that before the establishment of such an institute, a feasibility study report needs to be submitted. So, accordingly a feasibility report was prepared at a cost of TK. 35 lakh and was submitted to the government with a strong recommendation for the establishment of a 'National Institute of Biotechnology'. Based on this report, a Project Concept Paper was prepared by the Planning Commission in 1995 and submitted to the Pre-ECNEC meeting. And this, after many proposals and counter proposals, and revisions, was finally approved by the government in a meeting of ECNEC, held on May 12, 1999 and accordingly a Project Proposal was prepared with an estimated cost of Tk 2021.20 lakh. However, very soon it was realized that the floor space of the laboratories in the original Project Proposal was too meager for any good Biotechnology Research Institute. Therefore, before the initiation of the construction work a revised Project Proposal was prepared with an estimated cost of Tk 2768.24 lakh, having a total floor area for laboratories 2250 sq. m. instead of 1116 sq. m. The salient features of the institute are as follows:

- Name of the Project: National Institute of Biotechnology.
- Sponsor Organization/Ministry: Ministry of Science and Technology Government of Bangladesh.
- Estimated cost: Tk 2768.24 lakh (revised)
- Total Area of Institute Building: 3700 sq. m.
- Total Floor space of the laboratories: 2250 sq. m.
- No. of Laboratory: 6
- Total No. of Scientists to work: 100
- Expected year of completion: June, 2004.

The proposed six Laboratories/Divisions of the institute are:

- DNA Laboratory
- Plant Biotechnology
- Animal Biotechnology
- Fish Biotechnology
- Fermentation and Bioprocessing
- Bioenergy and Fertilization

The physical construction of the institute has already been started and the main laboratory building is expected to be completed by June 2002. Appointment of scientists for the project period is also underway.

NIB Objectives

The National Institute of Biotechnology, Bangladesh is going to be established with an aim to accelerate the research activities in the field of biotechnology in order to meet the ever-increasing demands in food, medicine, energy and industrial sector in the country. The institute will cater to the duel activities of taking up important research programmes in agriculture, health, medicine, industry and environment sector as well as giving support and guidance to other institutions working in the same areas in the country. Overall, the institute may cater to the following areas in order to boost up the application of biotechnology in the country:

- Research work on priority problems in agriculture, food, industry, veterinary and human health.
- Networking of important national projects like genome project, field testing, etc.
- Human Resource Development – manpower training in biotechnology, capacity building, bioinformatics and holding of regular seminars and symposia in order to disseminate the up-to-date knowledge on the subject.
- Policy Planning – act as a national focal point on biosafety, bioethics and biosurveillance, and also technology alert and assessment system.

- Technology Resource Centre – act as national centre for making use of proven, economically viable biotechnology on the shelf for fostering remunerative employment and also act as a seat of Biotechnology Park.

Some important research projects which may be initiated by NIB are:

- Improvement of productivity, nutritional quality and shelf life of food and animal feed products.
- Development of plant cultivars tolerant and/or resistant to stress from factors such as pests and diseases.
- Promotion of use of under utilized crops of possible future importance for human nutrition and industrial supply of raw materials.
- Development of improved diagnostic techniques and vaccines for prevention and spread of diseases of human as well as useful animals (livestocks).
- Utilization of various biotechnological techniques to improve the yield of fish, algae and other aquatic species.
- Development of appropriate methods to minimize the requirement for unsustainable synthetic chemical input and to maximize the use of environmentally appropriate products.
- Development of processes to reduce waste generation, treatment of waste before disposal and make use of biodegradable materials.
- Development of techniques to remove pollutants from the environment where conventional techniques are not available or are expensive, inefficient or inadequate.
- Development of processes to increase the availability of planting materials, particularly the indigenous varieties, for use in afforestation and reforestation and to improve sustainable yield from the forest.
- Promotion of the use of integrated pest management based on the judicious use of biocontrol agents.
- Promotion of the appropriate use of biofertilizers within national biofertilizer programmes.
- Promotion of the use of biotechnology relevant to the conservation and scientific study of the biological diversity and the sustainable use of biological resources.

R&D Priorities

In fixing the priorities in R&D activities in biotechnology, the sectors which are considered important for our country are health, energy, agriculture, industry and environment. Biotechnology can play a great role in development activities in all these sectors if R&D programmes are taken up judiciously and such programmes are supported adequately. Development of vaccines against viral, bacterial and protozoal diseases through modern genetic techniques. Vaccines for fertility regulation, production of drugs and pharmaceuticals, etc. call for proper investment in R&D activities in biotechnology and genetic engineering.

R&D activities should give priority to improvement of industrial strains of micro-organisms for production of those food supplements, drugs, vitamin, hormones, solvents and other chemicals which are now solely imported from abroad. Bioconversion of agricultural wastes into food, feed and fuels is another important area. Optimization of process parameters for maximising productivity so as to efficiently convert raw materials to finished products call for inter-disciplinary approach to the biological process with heavy input from chemical engineering.

Priorities in R&D work should include programmes on development of high yielding, stress tolerant varieties of food crops through modern genetic engineering techniques, biological nitrogen fixation, biofertilizers, bioinsecticides, etc. Emphasis should be given on the conversion of lignocellulosic wastes to biofuels, improvement of biogas technology from organismal and environmental (better bioreactor) point of view, development of energy plants, etc. Development of efficient activated sludge process for waste treatment, development of organisms for treatment of industrial pollutants, xenobiotics, etc. should get research priority.

In September 1993, a National Committee on Biotechnology Product Development was formed by the Government of Bangladesh to select potential biotechnological projects which could be leased out for commercialization. The committee, after careful considerations, recommended the following projects for utilizing under commercial venture:

- Rhizobial inoculants for use as biofertilizer.
- Yeast as protein supplement for poultry feed.
- Tissue culture derived post exposure anti-tabies vaccine.
- Tissue culture based foot and mouth disease vaccine.
- Bamboo saplings by *ex-vitro* and *in-vitro* methods.
- Biogas technology for fuel, fertilizer and environmental pollution control.
- Production of high quality potato seeds by using tissue culture.

Some of these projects are now being exploited on commercial basis. Besides, an MOU has been signed with one extrepreneur and one of the high yielding patented mutant strain (318/14) is under industrial trial for citric acid production by *Aspergillus niger.*

Biosafety Regulations

With all the benefits, which accrue from the bio-tech revolution, it appears that some of them are associated with potential risk as well, as has been described below:

(a) It is estimated that over the last three decades about half of the varieties of the world have been lost. One of the major risks in view of this arises from the fact that novel varieties which are commercially attractive, may replace some of the existing varieties unless proper attention is given to bio-conservation. Again, the genetic uniformity in plants and animals makes them vulnerable to pest and diseases. An epidemic caused by a mutant bacteria, pest or virus can cause havoc to a large number of plants or animals.

(b) So far farmers in the Third World have been able to develop varieties, organise production and also able to control the spread of disease as they were familiar with the indigenous plant or animals they were cultivating or breeding and the diseases which were likely to affect them, either by taking preventive measure or by providing the necessary treatment. With the introduction of bio-tech seed the dependence of farmers on the supplier would increase, as the supplier alone would have the total information, if any, on how to control disease problem. Because of the patent rights of biotech products the farmer would not be able to further develop the variety, or experiment with it. This would turn the Third World farmers and breeders into mere workers. The problems of terminator gene has created serious controversy in this regard.

(c) It is apprehended that biotechnology may also result in the substitution of a large number of natural products, such as flavours, added to beverage, food and other products. Their production, through cloning to increase the quality and quantity of a particular flavour, may affect production of indigeneous aromatic and medicinal plants. It may also affect the present genetic diversity, with consequent disadvantages, as mentioned earlier.

(d) The genetically controlled animal produced in animal farms would be cloned for increased quantities of proteins, but it may not suit the taste of consumers. The attempt to introduce casein gene in rice, though successful, may result in rice which taste like milk?
Again experiment on human genome has raised many ethical questions which deserve serious attention.

(e) Finally, environmental release of genetically manipulated products, where one does not know the possible impacts they would have on other living forms, may result in disaster particularly when a large number of them are released for testing or for specific purpose, i.e. to combat pests, etc. without assessing other possible harmful side effect.

(f) There is a tandency on the part of multinational companies to test biotech product without adequate safeguards over a period of time to know long term effects. If the laws of the country do not permit and cannot be violated, then the tests might be done offshore or in the Third World countries unless those countries are guarded by strong biosafety regulations.

(g) Scientists in their desire to gain name and fame or to earn large financial benefits by undertaking research in manipulating genes to develop new forms of life tend to violate the laws of the country and undertake tests without considering the environmental impart.

For proper handling of genetically modified plant, animal and micro-organisms it is essential to have safety guidelines, and for field application safety regulation is must to protect our environment from harmful effects of any of genetically modified organisms. The Ministry of Science and Technology, in collaboration with Plant Tissue Culture Society of Bangladesh, organized a workshop on Biosafety Regulation on 7-8 December 1997. A Task Force was formed to formulate biosafety guidelines and biosafety regulation, in the light of the recommendation of the workshop. And a biosafety guideline has been prepared which has recently been approved by the government.

Bioethics

'Bioethics' refers to the ethical or moral obligations/rules of behaviour/ professional standard of conduct dealing with biological research. Although literally the term 'Bioethics' refers to all biological research activities, actually the term has practically been evolved after the advent of biotechnological research activities.

Biotechnology in its present connotation is the science which primarily deals with the basic life substance, i.e. DNA or gene, and through genetic engineering technique it has now been possible to transfer gene from one organism to the other which are even totally unrelated. Thus, it has now been possible to have a gene of protein (insect toxin) from a bacterium like *Bacillus thuringiensis* (Bt) and integrate with the genome of a plant like cotton, maize, etc. and get an insect resistant variety. Earlier, before the introduction of biotechnology/genetic engineering techniques, such an act of unrelated gene transfer was not possible. Again, through the introduction of tissue culture techniques it is now possible to raise plants from cells, tissues or even protoplasts. Likewise animals like Dolly – a sheep – has been possible to be cloned from a single somatic cell. And it is now being aimed to raise human beings also from single cells (human cloning).

But, all the spectacular activities of biotechnological research have aroused a big question whether it is ethical to do all such type of research and what should be the guidelines or moral boundaries for working with 'gene transfer technology' as it contains potential danger too. And from this point of view the concept of 'bioethics' has emerged in the recent past.

In the advanced countries there have been quite lot of controversies regarding the bioethical guidelines. In the US alone till very recent past, biotechnological research were conducted under very stringent guidelines. Although at present in the US biotechnological research work, specially genetic engineering, is done under more relaxed guidelines, in other advanced countries strict rules and safety guidelines are followed. Most of the advanced countries working with biotechnology have 'biosafety guidelines' and also 'Act' passed by parliament which has to be followed strictly for doing research in the field of biotechnology.

Bangladesh, though belated in the field of biotechnology, for bio- ethical issues it is quite conscious. Biotechnology, specially the work on genetic engineering, is at present at a very nescent stage. But, before embarking on a broad-based research programme, Bangladesh government has given thoughts for enacting 'biosafety guidelines' and through an expert committee and a national seminar the national 'biosafety guidelines' have been framed to be followed by the scientists working in the area of Biotechnology.

The salient features of the biosafety guidelines are:

- Procedures and guidelines on the introduction, movement and field release of regulated materials.
- Physio-chemical and biological containment procedures and facilities.
- Guidelines for classification of micro-organisms according to their risk assessment.
- Good laboratory practices.
- Good industrial large scale practice.
- List of organisms according to different risk groups.
- The Universal Biohazard sign.
- Framework for risk assessment.
- Biosafety Committees.

Having set up the appropriate biosafety guidelines for working in the area of biotechnology, Bangladesh is now thinking to enact an 'Act' passed by the national parliament on the issue of biotechnology. The act to be named as 'The Bangladesh Biosafety Act-2001'is in its final stage of preparation prior to the submission to the government for placing before parliament as a bill for endorsement. The salient features of this 'Act' will be:

- Short title of the act.
- Definitions of different terms/connotations.
- Formation of National Committee on Biosafety of Bangladesh (NCBB).
- Power and Responsibilities of NCBB.
- Risk Management of GMOs.
- Contained use of GMOs.
- Field Release of GMOs.
- Public Deliberations/Awareness.
- Restriction on Certain activities related to GMOs.
- Working Principles for NCBB.

It is expected that after the 'Act' has been passed by parliament, biotechnological research in Bangladesh will be carried out under more congenial atmosphere and bioethical problems will be taken care more diligently.

In response to 'Bioethics' Bangladesh recently is going to support the International Convention against human cloning for reproduction to be placed on the agenda of 56th UN General Assembly. Bangladesh strongly feels that human reproduction cloning is against the human dignity and in the long run it may also cause havoc to mankind. Universal declaration on the human genome and Human Rights adopted in 1997 by UNESCO specifies that "Practices which are contrary to human dignity, such as reproductive cloning of human beings shall not be permitted". In pursuance of this declaration, any attempt to clone human being should be prevented through appropriate action/convention of United Nations, as it is contrary to 'bioethics'.

IPR and Biotechnology: Bangladesh Perspectives

A draft legislation on 'Biodiversity and Community Knowledge Protection Act' of Bangladesh has been prepared which is a positive step towards implementation of obligations on the part of the parties of Convention on Biological Diversity. But more things still have to be done. There is need for elabboration of detailed outline of the capacity building and stock taking with regards to access to genetic resources, traditional and community knowledge, transfer of technology issues related to bioprospecting of biodiversity. The stock taking may include assessments of the current legislative and regulatory frameworks on access to genetic resources, evaluation of strengths and weaknesses of the country's institutional and different stakeholders, which include particularly scientific, technological and administration set-ups.

Biodiversity and Community Knowledge Protection Act of Bangladesh.

On this issue also a draft has been prepared which is under active consideration of the Government of Bangladesh. The draft act deals primarily with community knowledge, collective innovation and community rights.

The Act shall be the principal instrument to guide, inform, determine, control, reinterpret and give effect, where necessary, to the rights and previlages granted, if any, to the innovations of any form that have used natural and biological resources including knowledge and culture of the country or of other countries with which Bangladesh has reciprocal recognition of similar acts or ordinances or laws.

The Act shall include all biological and genetic resources and related knowledge and their derivatives within the jurisdiction of the country, both *in-situ* and *ex-situ*.

Potentials and Challenges for Capacity Building in Biotechnology

A. Requirements for Capacity Building in Biotechnology:

1. *Infrastructure development:* For infrastructure development the following essential facilities are needed:
    - (a) Laboratory building
    - (b) Ancillary facilities: Growth Room, Green House, Animal House, Insectaris, Aquarium, Hatcheries, etc.
    - (c) Facilities for field experiments: specialized, well protected and isolated.
    - (d) Specialized laboratories: DNA Lab, Genetic Engineering laboratory, preferably P4 type.

2. *Manpower development:* For biotechnological work well qualified and experienced scientists are needed in the field of:
    - (a) Molecular biology,
    - (b) Genetic engineering,
    - (c) Pretein chemistry,
    - (d) Chemical engineering, etc.

3. *Equipment:* Biotechnology needs costly and modern equipment like:
    - (a) DNA synthesizer,
    - (b) DNA sequencers,
    - (c) PCR machine,
    - (d) Ultracentrifuges,
    - (e) Laminar Hoods, etc.

4. *Chemicals:* For biotechnological research work a regular supply of costly chemicals like enzymes (Restriction Endonucleases), radioactive substances, chemicals for DNA/RNA isolation, chemicals for *in-vitro* DNA/RNA preparation and synthesis, chemicals for enzyme isolation and characterization are needed.

B. Potentials for a Developing Country like Bangladesh

Although Bangladesh is one of poorest among the developing countries in Asia, yet for biotechnology development it has great potentials. These potentials lie primarily in its rich fertile agricultural land and biodiversity. Agriculture being the traditional industry of Bangladesh, agricultural biotechnology – be it plant biotechnology, animal biotechnology, fisheries or aquaculture – in every aspect Bangladesh has a great potentiality for future development. No where in the world such a fertile alluvial soil is available where plants could be grown so easily. The general mass are also well accustomed to different agricultural practices. What is needed is a good variety of plant or a good stock of animal/poultry/fish, etc. which can be developed through the modern biotechnological research. For this the country needs a good infrastructure and a team of well trained manpower for doing research in the modern field of biotechnology like genetic engineering, cell culture, cell fusion, protein engineering, enzyme technology, etc. Bangladesh has also a good potential for the development of industrial biotechnology based on agriculture. For this, small scale agricultural biotechnology may be encouraged, which is most suited for the country.

C. Constraints for Capacity Building

The constraints for capacity building in biotechnology in Bangladesh may be summarised as follows:

- Capital incentiveness of biotechnology.
- Poor economic condition of the country.
- Lack of venture capital.
- Lack of political will.
- Lack of adequate trained manpower
- Lack of incentives for biotech researchers.

But having a strong political will, these constraints, however difficult they may appear to be, could be easily overcome. Bangladesh Government is at present having a strong political will and is giving due incentives for the development of biotechnology in the country. A National Institute of Biotechnology is being built up which will take its due shape in the near future.

Suggestions for Future Improvement of Biotechnology in the Region of Asia

The following suggestions are being put forward for effective development of Biotechnology in the Asian region:

- ***Prioritizing biotechnology for national development by respective governments of Asian countries:*** This has to get the first priority because without strong political will the development of the subject will be delayed further as had been the case in the past.

- ***Task Force for biotechnology development:*** A strong Task Force, consisting of members from all Asian countries, well trained in biotechnology, has to be formed for chalking out future plan of action.

- ***Perspective plan for next 20 years:*** A perspective 20-year plan has to be drawn immediately so that no time is lost unnecessarily for lack of proper planning and an action plan also has to be formulated simultaneously.

- ***Common consortium for Asian countries:*** Most of the Asian countries are poor. Therefore, a 'common fund' for biotechnological development raised through voluntary or compulsory contributions, commensurating with the national capacity, may be raised in order to take action-oriented programmes common to all countries of the region. This will also avoid duplication of efforts by individual countries and save fund.

- ***Creation of centres of excellences under joint collaboration:*** Biotechnology is a subject of precision and excellence. Therefore, it needs centres of excellences. But, since for individual nations of

Asia it is difficult to build up such centres, a joint collaborative programme of the region may solve the problem.

Conclusion

Biotechnology has revolutionized the field of biology and genetic engineering is in the pivot of it. Bangladesh is on the threshold of entering into the arena. Joint programme of the countries of the Asian region may help in the accelerated development in the field of biotechnology which has great potentials for mitigating the suffering of the teeming millions of the region.

Discussion: GM Food Exports to Africa

In recent past it has been found that food aid to Africa contained genetically modified going as well. This has attracted attention of trade and food policy experts and media alike. This controversy has placed Cartegena protocol in new context. Here we present two dimensions of this subject.

— *Managing Editor*

Point: *by John Vidal*[*]

The US was accused yesterday of putting intense pressure on United Nations organisations, the European Union and individual countries to support the export of GM food aid to six African countries facing severe hunger in the coming months. Three countries were insisting that the food be milled to prevent the seeds being planted by farmers who may unwittingly pre-empt national legislation. Zambia's chief scientific adviser said that if his country accepted unprocessed food aid a precedent would be set undermining its legal and democratic systems. Together with Mozambique and Zimbabwe, which also initially refused to accept GM food aid, Zambia insists that the food must be milled before being handed out, because environmental risk assessments are impossible with its limited resources.

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[*] *The Guardian*, August 30, 2002.

At least a million tonnes of food is expected to be needed in the next six months to feed up to 12 million people in the six stricken countries. The US has offered more than 200,000 tonnes. The EU, the US Agency for International Development (USAid), the World Food Programme, the World Health Organisation and the UN Food and Agriculture Organisation have all been urged by the US government to publicly endorse the safety of the food, which is eaten in more than 35 countries. The EU has refused.

"We have been pushed around by the way the Americans have put pressure on this issue," the EU development commissioner, Poul Nielson, told Reuters. But the three countries who have put conditions on the food - and are preparing to mill it themselves - are angry at the pressure tactics used by the US, which has refused to offer conventional food or to mill the seeds. "We cannot be so irresponsible so as to risk the lives of innocent people," Mundia Sikatana, Zambia's agriculture minister, said. "We don't need to engage in biotechnology at this stage. If we engage in GM, our exports will be thrown overboard and that will cost thousands of jobs"

Non-government groups at the Johannesburg conference joined the row yesterday. Robert Vint, of Genetic Food Alert, said: "It is only because the US can prevent the World Food Programme from purchasing available non-GM food from southern nations that it is able to tell countries that they must buy GM maize, that they must buy it from the US and that it must be unmilled." Friends of the Earth said the jury was still out on GM foods and African countries should not be forced to accept the supplies. "Africans should choose what they eat, not have someone else decide for them," its spokesman, Nnimo Bassey, said.

But Andrew Natsios, the administrator of USAid, told reporters: "It's frightening people into thinking there is something wrong with the food ... and the consequence of it is that the relief effort is slowing down. It is very disturbing to me that some of the groups that are opposed to [genetically modified food] have chosen a famine to make their political points." Yesterday the World Bank announced that it was yet to set up a comprehensive study of the risks and opportunities of using GM and other farming systems in poor countries. It is expected to last three years. It is to be co-chaired by Dr Robert Watson, the bank's chief scientist, who was ousted as chairman of the UN's inter-governmental panel on climate change in May by the US government and the Exxon Oil Company, because of his remarks about the potential severity of global warming. The study was broadly welcomed by environmental groups, who urged the bank to take into account social factors and called on governments to put a moratorium on commercialising GM crops until the bank had reported back.

Meanwhile, small-scale farmers were pushed yesterday into the forefront of the debate about the future of GM crops in Africa by the companies and non-governmental groups which are lobbying in force. "I was given some GM maize seeds by Monsanto and they have done very well. I am very pleased. They save time and money," said George Phanto, a farm leader from KwaZulu Natal province. But Samuel Togo, a Tanzanian farmer who came to Johannesburg with an African grassroots organisation, was more cautious. "I have heard of GM seeds. I do not understand them, but I do not think they are good. I want to farm organically because it is better for the soil".

More than 150 people from the biotech industry are in Johannesburg. Monsanto yesterday said it had been lobbying ministers, African MPs and and government delegations. NGOs, with little access to the ministers and delegations, are trying to build alliances to oppose the planting of GM crops. GM food in Africa has been slow to take off, but hi-tech maize and cotton is now grown commercially in South Africa, with GM soya likely to be approved next week. GM cotton should be approved in Kenya and Uganda by the next growing season and Zimbabwe has conducted trials, according to Monsanto, which has been buying up large seed companies in Africa as a way to promote its GM seeds.

Counter Point: *by Devinder Sharma*[•]

Some years back, a keynote speaker at the International Famine Centre at Cork, Ireland, detailed how maize was loaded on ships bound for Britain at the height of the great Irish potato famine that killed some 1.5 million people more than 150 years ago. He paused and then lamented: "I wonder what kind of people lived at that time who were not even remotely offended at the sight of millions dying of hunger in the same village where the ships were being loaded." A hundred years later, the same class of people were largely responsible for the great Bengal Famine in 1943, in which an estimated 1.5 million to 3 million people perished. As Nobel laureate Amartya Sen explains in his now well-known theory of entitlements, the Bengal famine was not the result of a drastic slump in food production but because the colonial masters had diverted food for other commercial purposes. And if you are wondering whether the same evil class of the elite decision-makers has perished with the collapse of the erstwhile colonies, hold your breadth.

In the last 60 years or so, following the great human tragedy of the Bengal famine, food aid was conveniently used as a political weapon. But what is arguably one of the most blatantly anti-humanitarian act, seen as morally repugnant, is the decision of the United States Agency for International Development (USAID) to offer US $50 million in food aid to famine-stricken Zimbabwe provided that it is used to purchase genetically modified maize. Food aid therefore is no longer an instrument of foreign policy. It has now become a major commercial activity, even if it means exploiting the famine victims and starving millions. That is the official line at the USAID about the corn it has offered to Zambia, Zimbabwe, Lesotho, Mozambique and Malawi, where an estimated 13 million people face severe hunger and possibly live under the spectre of an impending famine after two years of drought and floods.

For the genetically modified food industry, reeling under a growing rejection of its untested and harmful food products, there is money in

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[•] Food and Trade Policy Analyst. His web page is www.dsharma.org hunger, starvation and death. Spearheaded by USAID, the industry has made it abundantly clear that it has only genetically modified maize to offer and was not willing to segregate. The WFP, which over the past few decades has for all practical purposes become an extension of USAID, was quick to put its rubber stamp. It had earlier helped the United States to reduce its grain surpluses by taking the genetically modified food for a mid-day meal programme for school children in Africa. President Mogabe may not be able to hold for long. He had earlier told Zimbabwe's Parliament on July 23: " We fight the present drought with our eyes clearly set on the future of the agricultural sector, which is the mainstay of our economy. We dare not endanger its future through misplaced decisions based on acts of either desperation or expediency." But then, the biotechnology industry is using all its financial power to break down the African resistance. Once the GM food is accepted as humanitarian aid, it will be politically difficult for the African governments to oppose the corporate take-over of Africa's agricultural economy. For the industry, Africa provides a huge market. Zambian President Levy Mwanawasa too has said that his people would rather die than eat toxic food. While Malawi says it has no choice but to accept GM maize, newspaper reports cite Mozambique, from where Malawi's food aid has to pass through, asking the WFP to cover it with plastic sheeting to avoid spillage while in transit.

Malawi incidentally is faced with famine after it was forced to sell maize to earn dollars for debt servicing. Explains Ann Petti for of the New Economics Foundation: Just three months before the food crisis hit, Malawi was encouraged by the World Bank "to keep foreign exchange instead of storing grain" Why? Because foreign exchange is needed to repay debts. Creditors will not accept debt repayments in Malawian Kwachas. Or indeed in bags of maize. Only "greenbacks" or other hard currencies will do. One of Malawi's key commercial creditors needed to have their debt repaid, according to Malawi's president, who in a BBC interview said the government "had been forced (to sell maize) in order to repay commercial loans taken out to buy surplus maize in previous years". President Muluzi said the IMF and the World Bank "insisted that, since Malawi had a surplus and the (government's) National Food Reserve Agency had this huge loan, they had to sell the maize to repay the commercial banks." So Malawi duly sold 28,000 tonnes of maize to Kenya. Under pressure from her creditors, led by the World Bank and the IMF, Malawi exchanged maize — her people's staple diet — for dollars.

The debate on biotech food however goes still further. After all, it is the commercial interest of America's sunrise industry. The biotechnology industry has always been quick to use agricultural economists to promote the unhealthy food on gullible populations. One of its most distinguished spokesperson, Dr Per Pinstrup-Andersen, former director general of the Washington-based International Food Policy Research Institute, said that Zimbabwe was using the food to play politics. Referring to President Mugabe's recent land-reform policies, he added: "I think it is irresponsible. Unless they know they can get enough food from elsewhere that is not genetically modified."

And how much quantity of grain is required to tide over the food crisis in central and southern Africa? A million tonne is all that the WFP estimates. It is surprising that the WFP as well as Pinstrup-Andersen are not aware of any other source of getting non-GM foodgrains for millions of hungry Africans. Ironically, the country which is laden with overflowing grain silos and an unmanageable grain reserves is the one to have come to the rescue of a famine-stricken Ireland in the nineteenth century. The first shipload of grain that came for the starving Irish was from India. And more recently, India had provided food on 'humanitarian' basis to the war-torn Iraqis'. India had also stepped in to fight immediate hunger in Afghanistan early this year. Earlier too, India had come to the rescue of Ethiopia at the height of the Ethiopian famine in the mid-1980s.

With 65 million tonnes foodgrains stockpiled in the open, and that too of non genetically modified grain, WFP will do well to purchase instead from India. With the grain from the reserves priced at Rs 4 to Rs 5 a kg (less than 10 American cents a kilo), the WFP will not find cheaper food available anywhere. But this will not happen; in other words, will not be allowed to happen. After all, the impending famine in Africa opens up a new market to sustain the multi-billion dollar US biotechnology industry. What happens in the bargain to the resulting crisis in human health and misery, and environment contamination from GMOs is none of the concern of the American grain merchants. In fact, it never was. At the height of the 1974 famine in the newly born Bangladesh, the US had withheld 2.2 million tonnes of food aid to 'ensure that it abandoned plans to try Pakistani war criminals'. And a year later, when Bangladesh was faced with severe monsoons and imminent floods, the then US Ambassador to Bangladesh made it abundantly clear that the US probably could not commit food aid because of Bangladesh's policy of exporting jute to Cuba. And by the time Bangladesh succumbed to the American pressure, and stopped jute exports to Cuba, the food aid in transit was 'too late for famine victims'. Food was then a political weapon. Food aid has now in addition become a commercial enterprise. Famine or no famine, the Shylocks of the grain trade must have their 'pound of flesh'.

Biotechnology Firms and Farmers Cooperatives

Joint ventures between agribusinesses and farmer-owned cooperatives are becoming increasingly common. Within the past decade Cargil, the world's largest agribusiness, has entered into at least eight joint ventures with farmer's cooperatives, and at least that many deals with other privately owned firms, large public companies such as Dow Chemical and Monsanto, and state-owned enterprises in China. At the same time, CHS Cooperatives, the second-largest farmer-owned agribusiness, has been combining many of its farm supply and feed operations with other cooperatives and private firms. CHS now has more than a dozen joint ventures or ownership stakes in separate companies, mostly formed within the past three years. In January (2002). CHS combined its five flourmills with Cargill's owned 16 to form Horizon Milling, creating a flour miller larger than Archer Daniels Midland, the previous industry leader.

The popularity of partnerships in the food industry is due to the increased market power that they bring. Customers for processed products, such as food ingredients, are getting the ability to demand lower prices from volume buying. In the past year General Mills bought Pillsbury for $10.4 billion and Pepsico paid US$14 billion for Quaker Oats. Agribusiness companies have responded by joining, shrinking supply and wrestling back the power. Other benefits of combining operations include reduction of capital costs, creation of better and more reliable relationships with suppliers, less risk for entering in new industry segments or in using new technologies, and faster access to markets by sharing a partner's strength.

However, such partnerships are not always successful. Cargill backed out of deals a year ago that never got launched, and CHS bought out Farmland

Industries last year after a one-year try at a petroleum venture. Also, Cargill helped form e-commerce joint ventures with other companies that crashed after lift off. In May last year, *Forbes Magazine* called Cargill the "most magnetic" company in agribusiness – that is, the company with whom others want to form partnerships. Some farm cooperatives believe that Cargill brings global marketing acumen to their ventures that they cannot match. And conversely, Cargill looks for partners that match its talents, technologies or other resources.

Cargill's first joint venture was with Miles Laboratories in 1974 when the two firms set out to create processes for making high fructose corn sweetener for the soft drink industry. The model was used in other countries in the late1970s and 1980s to form ventures in China, Hungary and elsewhere to comply with national laws that demanded local partners.

Cargill's 17 joint ventures include a deal with a Dutch firm to make lactic acid and a partnership with German firm to make lysine livestock feed ingredients. A good example is the Cargill-Dow Polymers joint venture, which began supplying renewable, agriculture based fibre materials to clothing makers and other manufacturers in November. In this case, Dow has the customer base and marketing experience to sell the fibres. Cargill brings the skills of processing to make the polymers derived from corn starch. For capital-intensive, thin-margin firms, the analysis typically centres on lowering costs to generate greater returns and reducing risk. Moreover, agribusiness and food manufacturing can be capital-intensive businesses, prone to cycles of over-capacity and vulnerable to world economic forces.

Sometimes, CHS finds itself competing with Cargill in some markets while its farmers are selling grains to Cargill in other markets. And at the same time, the two companies may be cooperating formally in the Horizon joint venture and working informally with shippers or overseas customers who are buying simultaneously from Cargill and CHS.

***Source*:** RIS, based on *Agrafood Biotech* No. 80, May 7, 2002.

EU Environment Committee Sees Heated GM Debate

Creating a genetically modified (GM) free label, the level of threshold for adventitious contamination and the need to label food which came from an animal fed on GM feed were some of the contentious issues discussed in a heated debate at the meeting of the European Parliament's Environment Committee.The reports by Karin Scheele on GM food and feed and Antonios Trakatellis on traceablility and labelling of GM food and feed were presented for the first time.

Commission representative Patrick Deboyser said the original intention of the Commission had been to make no changes to the labelling of GM foods and ingredients but to just introduce a GMO free label. The Commission had also consulted Member States and 13 out of 15 had said that they wanted new labelling which was not based on protein or DNA tests. The Community had organic labelling and a GMO free label did not offer any advantage. There was already food labelling based on documentary traceability rather than scientific tests. This included origin labelling as well as the new beef labelling where labels must now say where the animal was born, raised and slaughtered. Many members of European Parliaments (MEPs) said Parliament needed to take a precautionary approach.

It was demanded that food from animals fed on GM feed should be labelled. It was argued that just because something might be open to fraud did not mean it should not be done. If one legislates all the time to stop crooks and fraudsters, one ends up paralysing oneself. There was no difference between country of origin labelling for fruit and vegetables and the GM labelling proposed by the Commission. There was concern from other MEPs that labelling GM food more widely, to include chickens fed on GM feed for example, would result in 60 to 80 per cent of all food being labelled as GMO within five years.

Several MEPs agreed that it was "quite unacceptable" that food could be contaminated up to one per cent with a GMO banned in the EU. For the

Commission it was pointed out that the threshold would not apply to ban to GMOs but to GMOs which were approved elsewhere, had a positive risk assessment; but had not been formally approved in the EU due to the moratorium on new approvals.

Food from animals fed with genetically modified (GM) feed should be labelled and the threshold for adventitious contamination should be reduced from one to 0.5 per cent, according to MEP Karin Scheele, who presented her report to the European Union's Environment Committee this month. She also proposed to ban adventitious contamination from GM crops approved in other countries, but it was not formally approved in the EU. The report on the proposal for a Regulation on GM food and feed calls for a precautionary approach. The rapporteur said that food derived from animals fed "at any stage" with GM feed should be labelled.

The report deletes the controversial Article 5 in the Commission proposal which would have allowed adventitious contamination up to one per cent from GM crops not yet approved in the EU, provided the Scientific Committee on Food and European Food Safety Authority concluded they did not present a risk to health. Scheele argued that allowing a threshold for non-authorised GMOs would undermine the EU's legislation on bio safety. Scheele also wants the competent authorities to examine the documents in the case of products produced from GMO but containing no GM material. She called for "far more information regarding applications to be made public", saying that only confidential information should be kept back and that the public should be given reasonable access to the rest of the application. Scheele also wants the European Food Safety Authority (EFSA) to make its opinion public "immediately" and to give an assessment report and grounds for their opinion. The level of 0.5 per cent would be an aggregate value for contamination and should be based on the raw ingredients.

Source: RIS, based on *AgraFood Biotech* No. 80, May 7, 2002.

Intensive Trade War Feared on GM food

The public resistance to genetically modified food in the UK continues despite the increasing threat of a trade war between the EU and the US over the issue of labelling. The vast majority of people believe that labelling of GM food is essential and parents remain adamant that they would prefer not to feed it to their children. An opinion poll, carried out by Mori for Greenpeace, shows continued suspicion of GM food and crops despite claims from the biotech industry that both are gaining increased public acceptability.

The result shows that Tony Blair and the EU would get extensive public backing if the EU refused to bow to US demands that labelling of GM food be abolished. The US has already unofficially complained to the World Trade Organization (WTO) that labelling GM food unfairly discriminates against it. The next step, a formal complaint, might trigger a trade war. The poll, conducted early this year, showed that, given the choice, 51 per cent would avoid eating GM food, 40 per cent do not mind and 3 per cent would prefer to eat it. Only 18 per cent thought the benefits of GM outweighed the risk and 39 per cent the opposite, with 24 per cent thinking the benefits and risks were about the same.

But when it came to labelling, 76 per cent backed the EU position that consumers should be told products contained GM ingredients and only 6 per cent supported the US position that labelling should not be compulsory, with 20 per cent having no preference either way. Asked about pressure from the US to get the EU to license GM foods more quickly, 50 per cent supported the more cautious approach in Europe and only 13 per cent said that US impatience was justified, with 28 per cent having no preference.

The US food and drugs administration's view is that GM food is "substantially equivalent" to normal food and thus consumers should not be given the choice because it is not a health and safety issue. The EU has been told by the US that the high cost of labelling products is seen as a restraint of trade under WTO rules and the latter is considering making a formal complaint unless the EU gives way. Peter Kurz, minister-counsellor for the US embassy in London, told a House of Lords select committee that the US would make it clear to the WTO that the EU proposals are "not workable and could unduly impair trade". The EU environment commissioner, Margot Wallstrom, takes the opposite view and believes that labelling is essential for building public confidence in food products.

Greenpeace believes that the EU and the US are on a collision course over GM food. The scene is set for the defining conflict of the GM debate. The UK government, and the prime minister in particular, are caught in an awkward dilemma: they are desperate to avoid offending the US because of the special relationship, yet cannot reject demands for labelling without incurring electoral consequences. The Mori poll was conducted with 1,004 adults, aged 15 and over, interviewed face to face in their homes from April 18-22 at 193 sample points in the UK.

***Source*:** RIS, based on the *Guardian*, May 7, 2002.

GM Eggplants

Researchers at the Research Institute for Vegetable Crops and the University of Verona have produced a genetically modified (GM) seedless aubergine (eggplant). The new plants overexpress the plant hormone indole acetic acid (IAA). The plants are also 30-35 per cent more productive than conventional varieties in both greenhouse and field trials. Previous studies have shown that the application of IAA to flower buds can stimulate the development of fruit in the absence of fertilisation. This technique produces seedless fruit, but it is expensive because of the cost of the IAA and the labour required to treat the flower buds.

The researchers transformed a conventional aubergine variety with a flower-bud tissue specific transgene sequence comprising an enzyme involved in the biosynthesis of IAA, that was only active in the flower buds. It is critical that IAA production was confined to the flower buds as this hormone is involved in a range of different processes in other parts of the plant such as the response of the plant to light and gravity. The researchers carried out three trials, two of which were conducted in greenhouse and one in an open field site in central Italy. They compared yield weights of conventional and GM aubergines, and found that yield was increased in GM varieties in all three trials. From an economic standpoint the GM aubergines have three major advantages over conventional varieties. Firstly, they produce more fruit with an overall increase in productivity of at least 30-35 per cent. Secondly, the cultivation costs of producing seedless fruit was reduced and finally the GM aubergines could produce fruit in conditions normally considered too cool for conventional fruit production.

Source: RIS based on *Agrafood Biotech* No. 80, May 7, 2002.

France Sets Out New Farming Standard

The question of labelling has been the subject of much discussion, and a separate decree has been published, which must now be submitted to the European Commission for approval.

In the meantime, the French antifraud office (DGCCRF) will not be able to prohibit the use of the term "agriculture raisonnée" on labels. However, a spokesman said that a verification system had been put in place to prevent misleading claims and to ensure that there is no confusion with official quality marks. Some farmers' groups, such as the Coordination rurale and the agricultural development group Inpact, are opposed to "agriculture raisonnée", Les Marchés says. They describe it as a "dressing up of intensive agriculture," financed by the agrochemical industry. Inpact says it will maintain high yield levels, which are bound to require more water, fertiliser, pesticides, fuel, etc. It also attacked the inclusion of monoculture and intensive livestock systems in the scheme. "Consumers are being misled," the group claimed. On the whole, however, the scheme has the approval of farmers, food processors and consumers. It was particularly welcomed by the Permanent Assembly of Chmabers of Agriculture (APCA), which has promised to participate in its implementation.

***Source*:** RIS, based on Agra Europe, May 10, 2002.

Biotechnology in Brazil

Brazil's stubborn resistance to GM crops took the biotechnology companies by surprise. As part of its global strategy, Monsanto had purchased seed companies in Brazil. The Brazilian government had expressed its support for GM crops and was helping to fund the company's $180 million glyphosate production facility in the north-east of the country. In early 2000, Monsanto began stock-piling GM seeds to sell to farmers in the following planting season, after the anticipated authorisation.However, Greenpeace and the Brazilian Institute for Consumer Defence (IDEC) jointly appealed to the courts that the government had no authority to authorise Monsanto to produce GM seeds when the country's enviornmental legislation demanded that studies must first be carried out into the long-term health and environmental impacts of transgenic crops. In a historic ruling in May 2000, a Brazilian judge gave verdict in favour of the plaintiffs. Monsanto immediately appealed, but is still waiting for a final decision, which is being expected shortly.

Until recently, the anti-GM lobby had little support from Brazil's powerful farming community. Enticed by reports of high GM yields and low production costs, farmers in the south of Brazil began to purchase GM seeds smuggled over from Argentina. According to some reports, up to half of the soya planted in Brazil's most southerly state, Rio Grande do Sul, may be transgenic. Over the last year, however, GM soya has apparently become less popular. Non-GM soya planting areas have expanded northwards throughout Brazil, taking over first the plains of Mato Grosso and now moving into the Amazon basin. These farmers have been very successful with their non-GM exports, with some soya beans now going directly to Europe through the new port of Itacoatiara on the Amazon river. Over the last two years, Brazil's share of the world soya market has risen from 24 per cent to 30 per cent, while the US slice has declined from 57 per cent to 46 per cent. A farming association recently said that it would be "very foolish" for Brazil to authorise GM crops, for "we would risk throwing away a market we have worked very hard to win".

However, Brazil's agriculture minister, Mr. Pratini de Moraes, is a firm advocate of GM crops. On two occasions he tried unsuccessfully to authorise some GM varieties. On a trip to the US he said that Brazil was planning to invest heavily in GM crops and does not want to bear the risk of being left behind in the technological race. Over the last few months, the battle over GM has become more heated. Early this year, Mr. Anthony Harrington, former US ambassador to Brazil and now a lobbyist for Monsanto, held a private meeting with President Fernando Henrique Cardoso, now in his eighth and final year in office.

The environmentalists believe that if they can manage to postpone a final decision for a few more months, the balance of forces could change. Reports from Argentina say that GM soya is not living up to expectations; yields have been disappointing and the use of pesticides has soared, because of the emergence of disease.

Source: RIS, based on *AgraFood Biotech*, No. 80, May 7, 2002.

Document

The Protection of Plant Varieties and Farmers' Right Act, 2001, India

1. In pursuance of India's ratification of the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS), a new Act called "The Protection of Plant Varieties and Famers' Rights Act, 2001" has been enacted with the following objectives:-

(i) To provide for the establishment of an effective system for protection of plant varieties, the rights of farmers and plant breeders.
(ii) To encourage the development of new varieties of plants.
(iii) To recognize and protect the rights of the farmers for their contribution in conserving, improving and making plant genetic resources available for development of new plant varieties.
(iv) To stimulate investments in research and development.
(v) The Act although has many things in common with the UPOV, there are some very important differences namely, the Indian Act provides for farmers rights to reuse seeds from their crop and also sell them (not under a brand name), benefit sharing with farmers liability on supply of spurious propagation material and community rights.

2. Some Important Definitions

(a) "benefit sharing", in relation to a variety, means such proportion of the benefit accruing to a breeder of such variety or such proportion of the benefit accruing to the breeder from an agent or a licensee of such variety, as the case may be, for which a claimant shall be entitled as determined by the Authority under Section 26;

(b) "breeder" means a person or group of persons or a farmer or group of farmers or any institution which has bred, evolved or developed any variety;

(c) "convention country" means a country which has acceded to an international convention for the protection of plant varieties to which India has also acceded, or a country which has a law on protection of plant varieties on the basis of which India has entered into an agreement for granting plant breeders' right to the citizens of both the countries;

(d) "denomination", in relation to a variety or its propagating material or essentially derived variety or its propagating material, means the denomination of such variety or its propagating material or essentially derived variety or its propagating material, as the case may be, expressed by means of letters or a combination of letters and figures written in any language;

(e) "Essential characteristics" means such heritable traits of a plant variety which are determined by the expression of one or more genes of other heritable determinants that contribute to the principal features, performance or value of the plant variety;

(f) "essentially derived variety", in respect of a variety (the initial variety) shall be said to be essentially derived from such initial variety when it:

   (i) is predominantly derived from such initial variety, or from a variety that itself is predominantly derived from such initial variety, while retaining the expression of the essential characteristics that result from the genotype or combination of genotypes of such initial variety;

   (ii) is clearly distinguishable from such initial variety; and

(iii) conforms (except for the differences which result from the act of derivation) to such initial variety in the expression of the essential characteristics that result from the genotype or combination of genotypes of such initial variety;

(g) "extant variety" means a variety available in India which is:
    (i) notified under Section 5 of the Seeds Act, 1966 (54 of 1966); or
    (ii) farmers' variety, or
    (iii) a variety about which there is common knowledge; or
    (iv) any other variety which is in public domain;

(h) "farmer" means any person who:
    (i) cultivates crops by cultivating the land himself, or
    (ii) cultivates crops by directly supervising the cultivation of land through any other person; or
    (iii) conserves and preserves, severally or jointly, with any person any wild species or traditional varieties, or adds value to such wild species or traditional varieties through selection and identification of their useful properties;

(i) "farmers' variety" means a variety which:
    (i) has been traditionally cultivated and evolved by the farmers in their fields; or
    (ii) (ii) is a wild relative or land race of a variety about which the farmers possess the common knowledge;

(j) "Gene Fund" means the National Gene Fund constituted under sub-section (1) or Section 45;

(k) "propagating material" means any plant or its component or part thereof including an intended seed or seed which is capable of, or suitable for, regeneration into a plant;

(l) "seed" means a type of living embryo or propagate capable of regeneration and giving rise to a plant which is true to such type;

(m) "variety" means a plant grouping except microorganism within a single botanical taxon of the lowest known rank, which can be:

(i) defined by the expression of the characteristics resulting from a given genotype of that plant grouping;
(ii) distinguished from any other plant grouping by expression of at least one of the said characteristics; and
(iii) considered as a unit with regard to its suitability for being propagated which remains unchanged after such propagation and includes propagating material of such variety, extant variety, transgenic variety, farmers' variety and essentially derived variety;

3. Registerable Varieties

(1) A new variety shall be registered under this Act if it conforms to the criteria of novelty, distinctiveness, uniformity and stability.
(2) An extant variety shall be registered under this Act within a specified period if it conforms to such criteria of distinctiveness, uniformity and stability as shall be specified under the regulations.
(3) A new variety shall be deemed to be:

(a) novel, if, at the date of filing of the application the propagating or harvested material of such variety has not been sold or otherwise disposed of by or with the consent of its breeder or his successor for the purposes of exploitation of such variety:
    (i) in India, earlier than one year, or
    (ii) outside India, in the case of trees or vines earlier than six years, or, in any other case, earlier than four years, before the date of filing such application:

Provided that a trial of a new variety which has not been sold or otherwise disposed of shall not affect the right to protection:

Provided further that the fact that on the date of filing the application of registration, the propagating or harvested material of such variety has become a matter of common knowledge other than through the aforesaid manner shall not affect the criteria of novelty for such variety;

(b) distinct, if it is clearly distinguishable by at least one essential characteristic from any other variety whose existence is a matter of common knowledge in any country at the time of filing of the application.

(4) A new variety shall not be registered under this Act if the denomination given to such variety:
(i) is not capable of identifying such variety; or
(ii) consists solely of figures; or
(iii) is liable to mislead or to cause confusion concerning the characteristics, value, identity of breeder of such variety; or
(iv) is not different from every denomination which designates a variety of the same botanical species or of a closely related species registered under this Act; or
(v) is likely to deceive the public or cause confusion in the public regarding the identity of such variety; or
(vi) is likely to hurt the religious sentiments respectively of any class or section of the citizens of India; or
(vii) is prohibited for use as a name or emblem for any of the purposes mentioned in Section 3 of the Emblems and Names (Protection of Improper Use) act, 1950 (52 of 1950); or
(viii) is comprised of solely or partly of geographical name:

Provided that the Registrar may register a variety, the denomination of which comprises solely or partly of a geographical name, if he considers that the use of such denomination in respect of such variety is an honest use under the circumstances of the case.

4. Persons Who May Make Application

(1) An application for registration can be made by:
    (a) any person claiming to be the breeder or successor or assignee of the breeder of the variety; or
    (b) any farmer or group of farmers or community of farmers claiming to be the breeder of the variety; or
    (c) any person authorised in the prescribed manner by a person specified above or

(d) any university or publicly funded agricultural institution claiming to be the breeder of the variety.

(2) An application may be made by any of the persons referred to therein individually or jointly with any other person.

5. Form of Application

(1) Every application for registration under Section 14 shall:
  (a) be with respect to a variety;
  (b) state the denomination assigned to such variety by the applicant;
  (c) be accompanied by an affidavit sworn by the applicant that such variety does not contain any gene or gene sequence involving terminator technology;
  (d) be in such form as may be specified by regulations;
  (e) contain a complete passport data of the parental lines from which the variety has been derived along with the geographical location in India from where the genetic material has been taken and all such information relating to the contribution, if any, of any farmer, village community, institution or organisation in breeding, evolving or developing the variety;
  (f) be accompanied by a statement containing a brief description of the variety bringing out its characteristics of novelty, distinctiveness, uniformity and stability as required for registration;
  (g) be accompanied by such fees as may be prescribed;
  (h) contain a declaration that the genetic material or parental material acquired for breeding, evolving or developing the variety has been lawfully acquired; and
  (i) be accompanied by such other particulars as may be prescribed:

Provided that in case where the application is for the registration of farmers' variety; nothing contained in clauses (b) to (i) shall apply in respect of the application and the application shall be in such form as may be prescribed;

(2) Every application referred to in sub-section (1) shall be filed in the office of the Registrar.

(3) Where such application is made by virtue of a succession or an assignment of the right to apply for registration, there shall be furnished at the time of making the application, or within such period after making the application as may be prescribed, a proof of the right to make the application.

6. Term of Registration

(1) The certificate of registration issued under this section or sub-section (8) of Section 23 shall be valid for nine years in the case of trees and vines and six years in the case of other crops and may be reviewed and renewed for the remaining period on payment of such fees as may be fixed by the fules made in this behalf subject to the condition that the total period of validity shall not exceed:

(i) in case of trees and vines, eighteen years from the date of registration of the variety,

(ii) in the case of extant varieties, fifteen years from the date of the notification of that variety by the Central Government under Section 5 of the Seeds Act, 1966 (54 of 1966); and

(iii) in the other cases, fifteen years from the date of registration of the variety.

Farmers' Rights

(1) (i) farmer who has bred or developed a new variety shall be entitled for registration and other protection in like manner as a breeder of a variety under this Act;

(ii) the farmers' variety shall be entitled for registration if the application contains necessary declarations;

(iii) a farmer who is engaged in the conservation of genetic resources of land races and wild relatives of economic plants and their improvement through selection and preservation shall be entitled in the prescribed manner for recognition and reward from the Gene Fund:

Provided that material so selected and preserved has been used as donors of genes in varieties registrable under this Act;

(iv) farmer shall be deemed to be entitled to save, use, sow, resow, exchange, share or sell his farm produce including seed of a variety protected under this Act in the same manner as he was entitled before the coming into force of this Act:

Provided that the farmer shall not be entitled to sell branded seed of a variety protected under this Act.

Explanation-For the purposes of clause (iv), "branded seed" means any seed put in a package or any other container and labelled in a manner indicating that such seed is of a variety protected under this Act.

(2) Where any propagating material of a variety registered under this Act has been sold to a farmer or a group of farmers or any organisation of farmers, the breeder of such variety shall disclose to the farmer or the group of farmers or the organisation of farmers, as the case may be, the expected performance under given conditions, and if such propagating material fails to provide such performance under such given conditions, the farmer or the group of farmers or the organisation of farmers, as the case may be, may claim compensation in the prescribed manner before the Authority and the Authority shall after giving notice to the breeder of the variety and after providing him an opportunity to file opposition in the prescribed manner and after hearing the parties, it may direct the breeder of the variety to pay such compensation as it deems fit, to the farmer or the group of farmers or the organization of farmers, as the case may be.

Bio Web

In this column, ABDR puts together country/theme-specific web sites. In this issue, we give below a list of Japan-related web sites that could be of interest to our readers.

— Managing Editor

Government Agencies in Japan

http://www.mhlw.go.jp/english/index.html
Ministry of Health, Labour and Welfare

http://www.mext.go.jp/english/index.html
Ministry of Education, Culture, Sports, Science and Technology

http://www.meti.go.jp/english/index.html
Ministry of Trade and Industry

http://www.maff.go.jp/eindex.html
Ministry of Agriculture, Forestry and Fisheries

http://www.env.go.jp/en/index.html
Ministry of Environment

http://www.jpo.go.jp/index.htm
Japan Patent Office

http://www.enecho.meti.go.jp/
Agency of Natural Resources and Energy

http://www.cao.go.jp/index-e.html
Council for Science and Technology Policy, Cabinet Office

Public Research Institutes in Japan

http://www.riken.go.jp/
Institute of Physical and Chemical Research

http://www.aist.go.jp/index_en.html
The National Institute of Advanced Industrial Science and Technology

http://www.nite.go.jp/index-e.htm
National Institute of Technology and Evaluation

http://www.kazusa.or.jp/en/
Kazusa DNA Research Institute

http://www.nih.go.jp/niid/index-e/html
National Institute of Infectious Diseases

http://www.nies.go.jp/index.html
National Institute for Environment Studies

http://ss.niaes.affrc.go.jp/index_e.html
National Institute for Agro-Environmental Science

http://www.nig.ac.jp/index-e.html
National Institute of Genetics

http://www.nihs.go.jp/index.html
National Institute of Health Sciences

http://www.nfri.affrc.go.jp/en/
National Food Research Institute

http://www.nims.go.jp/eng/
National Institute for Materials Science

http://www.frontier.kyoto-u.ac.jp/
Institute for Frontier Medical Science

http://www.protein.osaka-u.ac.jp/index.html
Institute for Protein Research

Organizations in Japan

http://www.nedo.go.jp/english/index.html
New Energy and Industrial Technology Development Organization

http://www.jst.go.jp/EN/
Japan Science and Technology Corporation

http://www.jetro.go.jp/index.html
Japan External Trade Organization

http://www.jsa.or.jp/default_english.asp
Japanese Standards Association

http://www.jisc.go.jp/eng/index.html
Japanese Industrial Standards Committee

http://www.jpma.or.jp/12english/index.html
Japan Pharmaceutical Manufacturers Association

http://www.iip.or.jp/e/index.html
Institute of Intellectual Property

http://www.jhsf.or.jp/English/index_e.html
Japan Health Science Foundation

Source: *Japan Bioindustry Letters,* Vol. 18, No. 4, March 2002.

Company News

Canadian Lab Loses Amgen Backing

A Californian biotechnology company is pulling the plug on a successful mouse-genetics institute at the University of Toronto. The withdrawal of support from the Amgen Institute is the latest indication that biotechnology and pharmaceutical firms – faced with declining profits and empty drug pipelines – are losing some of their appetite for backing basic university research.

The six laboratories at the institute were considered to be exceptionally productive. But an agreement this week between Amgen, based in Thousand Oaks, California, and Toronto's University Health Network hands over the administration of the institute to the Ontario Cancer Institute (OCI) in Toronto. Although the financial details of the agreement have not been made public, Tak Mak, the Amgen Institute's director, says it will mean a sharp decrease in support from the Californian company. The institute's researchers will resort to individual grants for most of their funding. Since the institute's birth in 1993, its 50 or so scientists and technicians have been employed by Amgen, giving the company control of any intellectual property rights arising from their discoveries.

The move is the part of a larger restructuring at Amgen, one of the oldest and largest biotechnology firms, with 7,000 employees and sales last year of $4 billion. The reshuffle is expected to align research more directly with product development. Amgen will continue to provide support at a level appropriate to the new arrangement. It is estimated that Amgen's previous support amounted to around $8 million per year. Christopher

Paige, vice-president of research at the OCI, says there are no plans to reduce the size of the research group.

Source: RIS, based on *Nature*, 417, 2/5/02, p.4.

Novartis: Tapping into US Science

The decision by Novartis A.G. to move its global research headquarters to Cambridge, Mass., from Basel, Switzerland is as much a comment on an increasingly unfavorable European pharmaceutical market as it is on NVS's belief that the world's best science is currently found in the US While the company is not abandoning its European presence, it is expanding to follow the market and establish more intimate US regulatory ties, and certain technologies and development programmes will be transferred to the Cambridge facility.

According to NVS head of development Joerg Reinhardt, the main changes will be in high throughput screening (HTS) capacity. Currently, 80 per cent of the company's HTS is done in Basel, with the remaining 20 per cent done in the US However, that ratio is expected to change to 50-50 when NVS's Institute for Biomedical Research opens, which is set for the first half of next year.

Research staff in Basel will also be cut roughly to half from 2,800 to about 1,400 – a number the company said is enough to maintain the main Basel facility and its drug development needs for the European market. In addition, Reinhardt said, all US anti-infective research will be moved to the Cambridge facility, as well as some small-scale US cardiovascular research programmes.

In addition, establishing the Cambridge institute as NVS's global research headquarters means the company will be closer to the FDA. With the complications of both the US and European regulatory climate in the last few years, it is extremely important to stay very close to the FDA. While Reinhardt dismissed the idea that the move to Cambridge was a purely economic one, he did say the company realized that the Basel facility was not going to grow as expected. He contrasted this with the dynamism of the US market and science community.

Indeed, NVS already has a long track record of tapping into the US science spigot through partnering with US academic institutions, particularly those the West Coast. In 1998, NVS established the Novartis Agricultural Discovery Institute at the University of California at Berkeley to develop genomics-based agricultural products. The same year, NVS formed the Institute for Functional Genomics, which is situated next to the University of California at San Diego and the Scripps Research Institute, and is an example of what the company calls a "new approach" to coupling academics and industry.

According to Reinherdt, the approach involves adding financial incentives to researchers via stock options in companies spun out of institute research. To date, three companies have been spun out in San Diego, including Kalypsys Inc., which validates therapeutic candidates using cellular disease models; and Phenomix Corp., which develops physiological disease models to identify and validate genes and drug targets; and Syrrx Inc., which is using high throughput technologies to discover small molecule preclinical drug candidates.

For the moment, Reinhardt said the Cambridge institute will be based on a slightly different paradigm than the La Jolla institute. "For now, Cambridge will be a much more conventional, mainstream research organization. But we are not excluding that in the long-term, set-ups like La Jolla may be possible," he said.

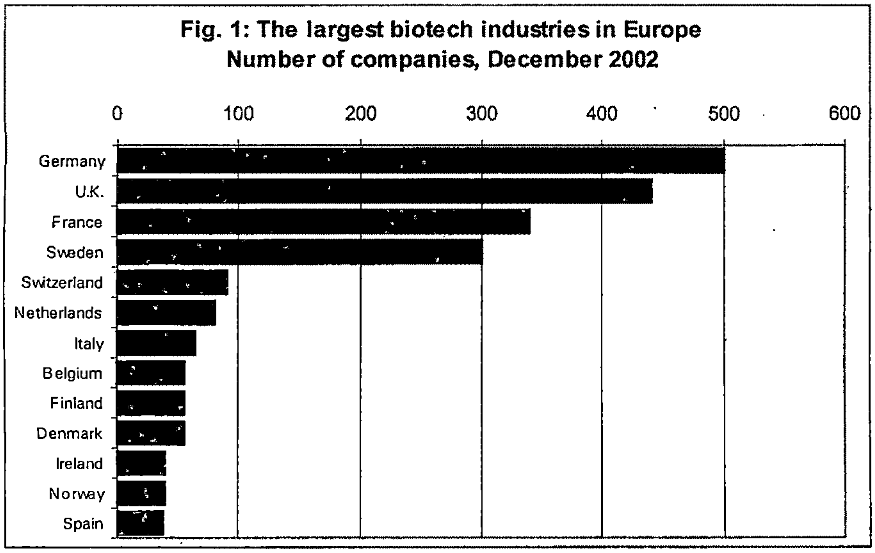
The institute will rent space from the Massachussetts Institute of Technology, and has chosen Harvard Medical School chief of cardiology and zebrafish pioneer Mark Fishman as its global director.

Reinhardt said Fishman will remain affiliated with Harvard, but in a capacity that has yet to be determined. However, he told *Bio Century* that Fishman's relationship will not be same relationship as that of Peter Schultz, head of the La Jolla institute, who spends 50 per cent time at the institute and 50 per cent as a professor at Scripps.

***Source*:** RIS, based on *BioCentury*, May 13, 2002, p. A11/12.

Biotechnology in Sweden*

After tremendous growth in recent years, the Swedish biotechnology industry today comprises more than 200 companies - Europe's fourth most numerous and the largest when measured in relation to both population and GDP. Sweden's success is the result of a strong biotechnology research tradition, big pharma consolidation, a boom in entrepreneurship and access to venture capital. Sweden's position builds on a long history of R&D achievements (Fig. 1). The presence of two of the world's largest



Source: European Commission, "*Innovation and Competitiveness in European Biotechnology*", 2002.

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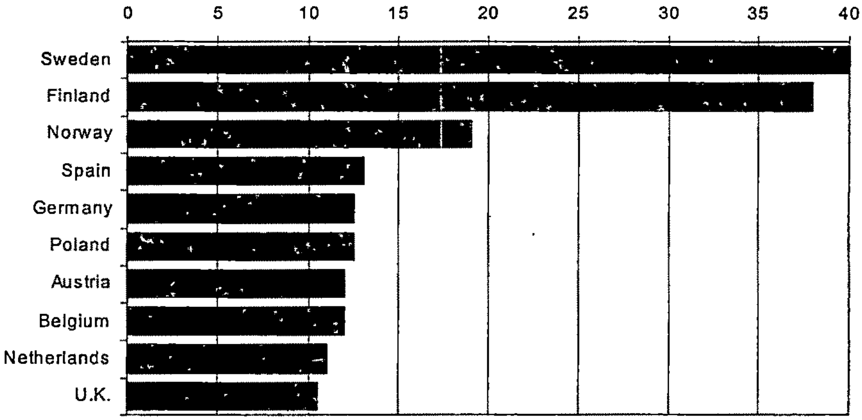
* Based on *Scientific American*, May 2002 p 52/6.

Fig. 2: Collaboration between business and academia
Share of European firms with co-operation arrangements with universities or government research institutions, 1994-96 (%)



Source: OECD, *Science, Technology and Industry Scoreboard*, 2001.

pharmaceutical companies, AstraZeneca and Pharmacia Corporation - with strong roots in Sweden and large investments in research and public health care - have also been important (Fig. 2).

Blood plasma substitutes and separation media based on polysaccharides were developed in Sweden in the 1940s and 1950s, and a range of equipment for use in research labs and later for the manufacturing of biotechnology drugs followed. Both the ultracentrifuge and the electrophoresis methods were early Swedish innovations in separation techniques.

In collaboration with Genentech, the Swedish pharmaceutical company Kabi Vitrum developed the world's first recombinant growth hormone, launched as Genotropin in 1987. Kabi later merged with Pharmacia, and Genotropin is now generating large revenues for Pharmacia Corporation. Functional genomics, proteomics, regenerative medicine, stem cell research and technology platform development are some examples of current Swedish research expertise.

Swedish research achievements have often been the result of successful cross-breeding among the fields of corporate and academic research, public health care and other institutions. An OECD study, covering business and academic research collaboration across industry sectors, showed this is more common in Sweden than anywhere else: 45 per cent of firms with more than 50 employees participate actively in joint R&D and other innovation projects with other organizations.

For biotech firms, this figure is even higher. A survey by the Swedish Agency for Innovation Systems (VINNOVA) showed that as many as 93 per cent of Swedish firms were involved in R&D collaboration with academic research groups. Collaboration is by no means restricted to domestic activities. Sweden has strong ties with the international scientific community through direct and active participation in global networks and collaborative relationships. A study of all life science-related articles published by Swedish authors between 1986 and 1997 showed that almost a third were co-authored by Swedes with collaborators from other countries. Ties were strongest with the US - 12 per cent of the articles were co-authored with US-based scientists.

Restructuring of the global pharmaceutical industry and increased entrepreneurial activity are key reasons for Sweden's rise as a biotech nation. Pharmacia, now Pharmacia Corporation, merged with Upjohn in 1995. The company, which prior to the merger was engaged in all aspects of drug discovery and development, went on to focus primarily on the later stages of the value chain. This change of focus has had a very productive effect on Sweden's biotech industry. In addition to spinning off biotech operations such as Amersham Biosciences, Biacore and Biovitrum (one of Europe's largest biotech firms), Pharmacia has supplied human resources to many start-ups. These are now staffed with board members, management and researchers who previously held senior positions at Pharmacia. Start-up activity has been significant in Uppsala, the former site of Pharmacia's headquarters.

Astra, which merged with Zeneca in 1998, has increased its R&D activities in Sweden, and even located its group R&D headquarters in Södertälje, south of Stockholm. Sweden has global R&D responsibility for four of AstraZeneca's seven therapeutic areas. Since the merger, the total number of employees in Sweden has increased by 2,000 people. Sweden is renowned for its ability to apply research progress in clinical practice, thereby stimulating the development of a large number of drugs and innovations. At an early stage, Sweden began building an advanced health care system, open to trying out new technology and techniques. A centralized public health care system also fostered the establishment of highly reliable systems of medical records. Common processes and working methods ensure the records' quality and reliability. Sweden has an outstanding collection of unique patient databases providing medical and genetic information. For example, Sweden has the most extensive twins register in the world, a unique tool in studying the relation between disease, genes and environment. Several databases include access to patients' medical history, as well as series of tissue and blood samples. UmanGenomics is a firm that offers gene analysis based on the unique biobanks available at the Umea University Hospital.

Printed and published by Dr. Nagesh Kumar, Director-General, on behalf of Research and Information System for the Non-Aligned and Other Developing Countries (RIS), and printed at Multiplexus (India), 94, B.D. Estate, Timarpur, Delhi-110 054. Ph. 3818103 and published at Zone IV-B, Fourth Floor, India Habitat Centre, Lodi Road, New Delhi-110003.

About the RIS

The Research and Information System for the Non-Aligned and Other Developing Countries (RIS) is an autonomous research institution established with the financial support of the Government of India. RIS is India's contribution to the fulfilment of the long-felt need of the developing world for creating a 'Think Tank' on global issues in the field of international economic relations and development cooperation. RIS has also been envisioned as a forum for fostering effective intellectual dialogue among developing countries.

RIS is also mandated to function as an advisory body to the Government of India on matters pertaining to multilateral economic and social issues, including regional and sub-regional cooperation arrangements, as may be referred to it from time to time. RIS functions in close association with various governmental bodies, research institutions, academicians, policy-makers, business and industry circles in India and abroad. RIS has conducted policy research and other activities in collaboration with other agencies, including United Nations-Economic and Social Commission for Asia and Pacific (UN-ESCAP), United Nations Conference on Trade and Development (UNCTAD), United Nations University (UNU), Group of 77, Non-Aligned Movement, SAARC Secretariat, Asian Development Bank (ADB), The World Bank, and the South Centre.

RIS publication programme covers books, research monographs, occasional papers and discussion papers. It also publishes journals entitled, *RIS Digest*, *Asian Biotechnology and Development Review*, and *South Asia Economic Journal*.